Report Number 58

RECOVERY FROM FATIGUE

Annual Summary Report

Mary R. Cook, Frederick J. Evans, Harvey Cohen, and Martin T. Orne

June 1973

(For the period 1 August 1972 to 30 June 1973)

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U. S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND
Fort Detrick, Frederick, Maryland 21701

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Contributors to the Pennsylvania Hospital
Philadelphia, Pennsylvania 19107
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ABSTRACT

Three studies are reported on: (1) A factor analytic investigation of questionnaire data to help establish the attributes of individuals who habitually nap as opposed to others who do not. (2) A study over eight sessions comparing the physiological napping behavior of habitual nappers versus individuals who do not normally nap. (3) A study currently in progress evaluating the effect of napping on performance in partially sleep-deprived individuals. Previous observations about the deleterious effects of naps involving delta sleep on performance immediately on awakening were again observed. One of the more striking findings is that nappers seem to perceive descending Stage I sleep as more like being awake while non-nappers describe it as sleep. Further, it would appear that daytime napping serves appetitive functions in addition to facilitating recovery from fatigue in non-sleep-deprived habitual nappers. The likelihood that there are functional differences in napping behavior between nappers and non-nappers is discussed.

Descriptors: Fatigue, Napping, Performance, Sleep, Psychophysiology, Electrodermal Response, Vasomotor Response

RECOVERY FROM FATIGUE

Progress Report, 1972-1973

Each of us can, merely by reflecting upon past experience, document the importance of sleep, especially the uncomfortable consequences of sleep loss and its deleterious effects on mental functioning. The requirement to remain awake for prolonged periods leads rapidly to general feelings of fatigue and eventually to decrements in performance on tasks requiring sustained effort. While the effects of circadian rhythms on the one hand, and motivational factors on the other, serve to moderate both objective and subjective consequences of sleep deprivation, the deleterious effects are often cumulative within broad ranges. Just as the effects of food deprivation are by no means monotonic, so the effects of sleep deprivation appear to be no less complex and, perhaps in some aspects, more insidious.

Ultimately we would hope to contribute to a better understanding of the interrelationship between the various mechanisms involved in sleep deprivation. Our studies approach these basic issues by focusing on the mechanisms of recovery from fatigue. Most specifically, we have been impressed by considerable anecdotal evidence which suggests that some individuals can maintain peak performance over long periods of time by the judicious use of short periods of sleep or naps. Since these individuals seem able to prevent, or at least ameliorate, the effects of sleep loss, it seems reasonable to expect that at least for some individuals naps can serve important restorative functions. Our program of research is designed to elucidate the physiological and psychological nature of naps and determine when and how they can serve a restorative function.

The focus on napping behavior stems from both practical and theoretical considerations. From a practical point of view, individuals may be able to replace, or at least spread over time, their usual sleep requirements by napping for relatively short periods, thereby preventing subjective discomfort as well as performance decrements. To the extent that this ability is specific to some individuals, it may represent a skill which can, with sufficient understanding of the mechanisms involved, be taught. From a theoretical point of view, an understanding of the restorative effects of napping may help clarify the functions of sleep itself. Such a theoretical understanding would, of course, in turn ultimately have profound practical consequences.

The initial study of daytime napping which was carried out last year suggested that moderately sleep-deprived individuals, given the opportunity to engage in daytime naps, showed less improvement in performance the more delta (slow wave) sleep they obtained. This counter-intuitive observation seemed to contradict the findings of previous sleep deprivation studies which had shown that delta sleep is preferentially replaced and, further, that when sleep is limited, the absolute amount of delta sleep is maintained at the cost of other stages. It was data such as these which had led to the view that delta sleep is a biological necessity; however, it is also true that with increasing age individuals show progressively less delta sleep, and some individuals do not appear to require any slow wave sleep.

Within our college-age subject population, a relatively large amount of nighttime delta sleep would be expected, and it is precisely in such populations where the amount of delta sleep is preferentially maintained. It is conceivable, however, that delta sleep deficits can be effectively compensated for only during long periods of sleep, while relatively short delta naps turn out to be counterproductive. On the other hand, short periods of <u>non</u>-delta sleep appear to increase some individuals' subjective comfort and objective performance.

Three major lines of investigation have characterized the work carried out during the past year. We continue to be impressed with the distinction between individuals who habitually nap and those who do not, and feel that a study of these two kinds of individuals might shed considerable light on the nature of effective napping and in our ultimate goal of teaching effective napping.

With this goal in mind, first, a factor analysis of questionnaire data concerning napping behavior was carried out in order to evolve more adequate means of characterizing some of the psychological and behavioral differences between nappers and non-nappers. This study, to be reported below, has led to the development of more appropriate questionnaires which are currently being validated and will prove useful in our future research.

Secondly, a major pilot study comparing nappers and non-nappers was carried out over eight experimental sessions. This study was concerned with normal napping behavior and sought to understand the possible physiological differences between the naps of individuals who habitually nap and those who actively dislike napping and normally avoid doing so. Further, among nappers themselves we hoped to find physiological differences between those naps which subjects describe as satisfying versus those occasional ones which they find as dysphoric.

The third and major investigation involves the study of performance (a.) under normal circumstances, (b.) with minimal sleep deprivation, and (c.) following a nap. By the use of this model, we thereby hope to clarify the nature of the recovery functions of short periods of sleep. This study involves five afternoon sessions for each subject and is currently in progress. To date, only six subjects have completed all five sessions, and therefore only very preliminary findings are available.

Each of the studies in these three lines of investigation will be discussed separately below.

STUDIES OF SELF-REPORTED SLEEP PATTERNS

Although there has been a vast amount of research on the objective parameters of sleep, relatively little attention has been given to those aspects which an individual would typically use to describe his subjective experience of sleep. A person may report that he certainly slept deeply, or that he habitually has trouble falling asleep, yet he remains blissfully unaware of the existence of his REM percent, or the time to his first EEG sleep spindle, or other objective measures used by the researcher to describe sleep behavior objectively. Self-report data have been limited primarily to clinical aspects of sleep pathology and to dreams. Thus, patients are often asked to keep sleep diaries, or during psychotherapy to report the dreams they remember. The subjective reports of patients with insomnia are, of course, only too well known. With these clinical exceptions, however, little is known about how people in general describe their own sleep habits in terms of such common sense variables as how well they sleep, when they sleep best, how easily they awaken, how easily they fall asleep, to what extent they awaken or are awakened during the night, and so on. Any attempt to explore the quality of sleep, and those factors which might increase the effectiveness of sleep, should be sensitive to the experiences of the individual as well as to the objective indices of his sleep behavior.

The task of exploring subjective factors involved in sleep efficiency cannot be limited to the collection of self-report data, though documenting the parameters of self-reported sleep patterns is an essential first step.

However, when a person asserts he has difficulty in falling asleep, we cannot assume that he would necessarily take longer to fall asleep by EEG criteria than another person who claims he always falls asleep easily. For example, in our previous work studying responses to verbal suggestion during sleep, those subjects who were able to respond during sleep to suggestions previously administered during REM sleep reported that they fell asleep more quickly than unresponsive subjects, but in fact it took them significantly longer to fall asleep in the laboratory than it took the unresponsive subjects (Evans, Gustafson, O'Connell, Orne, & Shor, 1969). Clearly, subjective reports of sleep require validation and comparison with objective sleep criteria. However, it seems appropriate to begin by analyzing the subjective experience reports themselves in order to determine the extent to which meaningful experiential patterns exist, and to what extent self-reported sleep patterns co-vary, before attempting to evaluate them with EEG sleep criteria.

Such a shotgun approach could be conducted in three ways, each of which has its limitations. First, it would be possible to objectively define criterion groups such as "good" and "poor" sleepers (Monroe, 1967) or "long" and "short" sleepers (Webb & Friel, 1971) and then investigate which of a number of possibly relevant variables discriminate between these criterion groups. The success of this approach depends on how accurately the relevant variables are selected. Second, it would be possible to concentrate on the correlates of a particular phenomenon of sleep, and to explore those aspects of sleep experiences which relate to it.

Investigating the correlates of napping is an example. Some proposed studies using this approach are central to our long term aims, and will be summarized below. However, the major limitation of this approach is the notorious unreliability of single items of experience of this kind. The problem is partly circumvented by the third approach involving multidimensional analyses of a large number of possibly relevant aspects of sleep to determine those phenomena which cluster together. This approach simplifies the data to the extent that a small number of item-clusters can be used to replace the original larger number of variables, and these clusters can often be scored more reliably than the single items constituting the clusters. For our purposes factor analysis would seem an appropriate method to explore interrelationships among self-reported aspects of sleep behavior.

Procedure

Subjects are routinely administered a sleep questionnaire when they participate in ongoing research in the laboratory. This questionnaire (see Appendix A) contains 33 items covering a wide range of questions about sleep habits. For example, question 17 reads:

"Do you take catnaps during the day?"

Subjects are asked to check the most appropriate of five response choices (which are the same for all except the last two questions*):

___always ___usually ___sometimes ___rarely ___never.

*The last two questions ask subject to circle his preferred times of sleep (which will not be reported here), and to circle the number of hours (4 through 10, or more than 10, arbitrarily scored as 11) he typically needs to sleep at night.

Each question is assigned a value of 1 to 5, and in the data reported below, a low score represents a response of "always." Responses of 90 volunteer male students were intercorrelated and factor-analyzed using the Principal Components method. The six factors contributing the largest variance were rotated by the Varimax method (unities were inserted in the diagonals). Additional hand rotations were completed where justified, as the Varimax procedure tends to maximize high factor loadings, rather than maximizing the number of zero loadings which is a more appropriate solution for the simple structure criterion. A second cross-validation sample of 180 students was analyzed in a similar fashion. Factor scores were estimated for the three main factors in each sample.

Because of the emphasis on napping in our current work, we have also analyzed the questionnaire data in terms of the napping question described above. For the purposes of this report, a napper is an individual who reports that he catnaps "always" or "usually," while a non-napper reports that he naps "rarely" or "never." Those using the middle category were eliminated from this part of the analysis.

Results

Factor Analysis of Sleep Questionnaire

Several significant factors emerged in both samples. No evidence of a general factor of subjective sleep quality was obtained. The largest factor accounted for only 14.2 percent and 15.8 percent of the total variance in the two samples, certainly too small to be considered as a general factor. The six factors rotated accounted for 44 percent and 49 percent of the total variance of the intercorrelation matrix.

Factor matching was conducted primarily by inspection of the significant factor loadings. On the whole, matching was quite clear-cut. Correlations between the two sets of factor loadings were mostly high. The correlation between a given factor and its matching factor in the second sample was always higher than its correlation with any other factor in either sample.

Tables 1 through 5 present the main variables defining each factor in both samples. The questionnaire item number and a summary of the content of the item is presented. All items are listed which have factor loadings higher than .35 in one or both samples. However, where there are inconsistent factor loadings in the two samples, the item is presented in the lower half of the table.

<u>Factor 1: Ease of Sleeping (Control of Sleep)</u>. This factor, the largest after rotation, accounts for 24 percent and 20 percent of the reliable variance in the two samples. The Pearson correlation between the two sets of factor loadings is a satisfactory .82. The individual who scores highly on this cluster reports that he falls asleep easily at night, also falls asleep easily in a variety of other surroundings (e.g., during a movie or concert or in a car or plane), and in general can fall asleep "at will." The napping item is therefore a major defining variable. There is a less clear tendency for this person to claim to be a deep sleeper, who likes to sleep and who sleeps a little longer at night than other people.

It seems reasonable to call this an "ease of sleeping" factor, as it involves those items that are concerned with an individual who is ready, willing, and able to fall asleep at any time and in any place. There is a hint that the ease of falling asleep has psychodynamic overtones. In another context, we found that nappers felt less anxious after a satisfactory nap than before it. Perhaps the readiness to sleep involves, in part, an ability to use sleep as a defense mechanism (as in the item about the tendency to oversleep before important appointments), or alternatively to be able to efficiently utilize the 24-hour day to obtain sleep at the most appropriate time. Selecting individuals with extreme scores on this ease of sleeping dimension would hopefully maximize the possibility of exploring the correlates of sleep efficiency in future studies.

Place Table 1 about here

Factor 2: Insomnia. This factor accounts for 20 percent and 16 percent of the reliable variance. Because of some inconsistencies in the lower factor loadings in the two samples, the correlation between the loadings is only .54. The subject with a high score on this factor has difficulty in falling asleep, particularly before examinations or similar important events. This is the only factor in which the tendency to take sleeping medications is involved. This subject reports that he cannot fall asleep "at will" and tends to work best early in the day. Within the limits of the items on the questionnaire and the student sample, we feel

Table 1. Sleep Questionnaire: Ease of Sleeping (Control of Sleep)

Item		92*	180*
9	Fall asleep easily	.53	.50
17	Take daytime naps	.62	.49
18	Oversleep before appointments	.56	.39
19	Difficulty falling asleep	-.43	-.44
25	Sleep during movie, concert	.51	.47
26	Sleep at will in plane or car	.66	.63
28	Go to sleep at will	.65	.62
6	Deep sleeper	.66	.20
12	Light sleeper	-.66	-.14
22	Like to sleep	.17	.55
32	Hours of sleep per night	.16	.40
	% Total variance	11.6	9.3
	% Reliable variance	23.8	19.7

*Refers to sample size in Tables 1 through 5.

that this is an "insomnia" factor. Except in those studies designed to investigate sleeping difficulties, subjects with a high score on this factor may well turn out to be poor risks for sleep studies. Of course, if it turned out to relate to objective indices of sleep, this dimension could also serve as an important clinical screening device.

Place Table 2 about here

Factor 3: Dreaming. Although in some aspects this is the most clearly defined dimension, it is a puzzling entity. It accounts for about 16 percent of the reliable variance in both samples, and the correlations between the factor loadings in the two samples is .81. The high-scoring subject reports he dreams almost every night, never has dreamless sleep, dreams in color, and dreams about the previous day's experience. He also talks in his sleep. Clearly, the factor involves dreaming. Our first inclination was to dismiss it as a general interest factor. Naive subjects typically refer to sleep research as "dream studies," and the popular conceptions of the dream process are the relevant variables. However, several questions dealing with dreams are not correlated with this factor. The occurrences of nightmares, and the claimed ability to be able to control dream content, define a less clear factor described below. It is unclear whether this factor has any psychological basis relevant to this research program. Nevertheless, this factor emerges most strongly in both the unrotated and computer-rotated solutions, and cannot be ignored.

Table 2. Sleep Questionnaire: Insomnia

Item		92	180
9	Fall asleep easily	-.55	-.61
19	Difficulty falling asleep	.65	.64
20	Take sleep medication	.37	.40
29	Trouble sleeping before exam	.69	.47
3	Nights of dreamless sleep	.45	.08
10	Get up during night	.40	-.02
18	Oversleep before appointments	.27	.39
28	Sleep at will	-.30	-.49
30	Work best late	-.51	.20
	%Total variance	9.7	7.3
	% Reliable variance	19.9	15.5

Place Table 3 about here

<u>Factor 4: Inability to Maintain Sleep</u>. In some ways this dimension is enigmatic. It is not consistently defined in both samples nor was its existence predictable. It accounts for only 12 percent of the variance in the first sample, but 20 percent of the reliable variance in the larger sample. This difference is mainly due to the very high loading in the second sample of a question that is repeated in positive and negative formats (are you a deep sleeper? are you a light sleeper?). The consistent items include awakening to an expected sound, awakening during the night, and difficulty in sleeping in strange surroundings. A subject with a high score on this factor has difficulty in <u>staying</u> asleep at night although he does not necessarily report difficulty in <u>falling</u> asleep.

The appearance of this third factor concerned with the onset and maintenance of sleep is important for an understanding of sleep behavior. A simple-minded view of sleep would probably place "insomnia" and "deep sleep" or the "ease of falling asleep" on a single continuum. The present data suggest that insomnia (difficulty in falling asleep), the ability to fall asleep easily and at will, and the difficulty in staying asleep throughout the night are conceptually independent aspects of sleep behavior, at least so far as subjects' reports are concerned.

Place Table 4 about here

Table 3. Sleep Questionnaire: Dream Factor

	Item	92	180
1	Do you dream at night?	.82	.82
2	Nights of dreamless sleep	-.81	-.79
11	Do you talk in your sleep?	.39	.48
13	Dream about daytime happenings	.58	.42
14	Dream in color	.35	.52
	% Total variance	8.0	7.9
	% Reliable variance	16.4	16.8

Table 4. Sleep Questionnaire: Inability to Maintain Sleep

	Item	92	180
15	Awaken to expected sound	.48	.59
27	Set yourself to awaken at chosen time	.52	.42
5	Wake up during night	.54	.53
4	Unable to remember dreaming	.49	-.19
6	Deep sleeper	.24	-.81
10	Have to get up at night	.29	.37
12	Light sleeper	-.05	.76
21	Trouble sleeping in strange surroundings	.27	.42
	% Total variance	6.0	9.5
	% Reliable variance	12.5	20.2

<u>Factor 5: Control of Sleep Mentation</u>. This is a poorly defined factor accounting for 16 and 12 percent of the reliable variance. This high scoring subject can change dream content at will, can decide ahead of time what he should dream about, and can perhaps incorporate external sounds into his dreams. Several items have high loadings on both factors, but of the opposite signs. This indicates the possibility that further rotation would have yielded another as yet unidentified factor--a possibility strongly supported by a second factor with similar loadings in the second sample which accounts for a significant proportion of the variance.

In spite of these problems, the factor seems to tap the purported ability to control and change one's dreams and sleep habits. Evidence supporting such contentions have been rather meager (see review in Evans, 1972). To the extent that this is a reasonable interpretation, this factor is of most interest to our earlier work in terms of whether it would predict the sleep responsive subject (Evans et al., 1969).

Place Table 5 about here

<u>Factor 6: Sleep Addiction--the "Long" Sleeper</u>. A factor accounting for 11 percent of the reliable variance in the first sample had no counterpart in the second sample. Only three items loaded significantly: the ability to sleep late on Sundays (item 16: .58), likes to sleep (item 22: .61) and tends to sleep more than 8 hours per night (item 32: .74). If it were to occur reliably in other samples, it might be possible to relate this factor

Table 5. Sleep Questionnaire: Cognitive Control of Sleep

	Item	92	180
23	Can change dream content at will	.53	.43
24	Decide beforehand what to dream	.65	.41
30	Work best late	.53	.46
5	Wake during the night	.40	-.45
7	Awakened to find sound in dream was real	.56	-.27
8	Nightmares	.42	-.55
21	Trouble sleeping in strange surroundings	.44	-.04
	% Total variance	7.9	5.7
	% Reliable variance	16.2	12.7

to the current distinction between "long" and "short" sleepers, i.e., individual differences in the amount of sleep required.

Predictive Value of Sleep Questionnaire Factors

Napping Study. So far we have not been able to systematically validate these factor interpretations by directly comparing factor scores with standard sleep criteria. However, scores on the first three factors were estimated for the study described later in this report involving seven subjects who completed the serial subtractions task following napping. Correlations between the "dreaming," "ease of sleep," and "insomnia" factors with performance and sleep measures are reported in Table 6. Caution must be exercised in interpreting these correlations on such a small sample. Several of the correlations are high, and they are in predictable directions for the "ease of sleep" and "insomnia" factors (as we are uncertain of the meaning of the dreaming factor, we would not make any guesses about the nature of these correlations). For example, subjects were allowed to sleep until the criterion sleep state for testing performance was reached. Those subjects most able to sleep effectively required less time to cycle through these sleep stages to achieve the target stage. The insomnia factor correlated significantly with the proportion of time subjects were unable to sleep.

Place Table 6 about here

Table 6. Correlations between Sleep Questionnaire Factor Scores and Napping Performance (N = 7)

	Dreaming	Ease of Sleep	Insomnia
1. Mean performance time	-41	20	40
2. Number of performance errors	42	-12	45
3. Estimated time since E spoke	-44	30	32
4. Ss estimated sleep depth	65	-55	12
5. Performance decrement	-20	-18	-16
6. Total time	53	-37	-16
7. Sleep time	42	-51	30
8. Stage 2 time	68	-51	20
9. Delta time	-29	00	28
10. Sleep onset time	39	-30	19
Proportion of experiment asleep	-07	-12	-57

Prediction of Napping Reports. A second indirect test of the validity of the ease of sleep factor arises with its correlation with the napping question (number 17). This correlation is .67 and .57 in the two samples of 92 and 180 respectively. Although these correlations are highly significant, they are to some extent spurious, as the napping question loads highly on this factor. The correlation between the napping item and the dream and insomnia factors are, as expected, insignificant.

Some Parameters of Sleeping Behavior and Napping

So far, the way in which aspects of self-reported sleep behavior cluster together has been discussed. In Table 7, basic parametric data are presented for the sleep questionnaire. The mean rating (1 = always, 5 = never) for each question is presented ($\underline{N} = 92$). Means for the larger sample ($\underline{N} = 180$) correspond very closely to these values, and only three items differ significantly between the two samples. In the larger sample, subjects were less likely to claim they could fall asleep during a movie or a concert (4.11 and 4.33 respectively, $\underline{t} = 2.25$, $\underline{p} < .05$) and less likely to report they slept late on Sundays (2.05 and 2.38, $\underline{t} = 2.47$, $\underline{p} < .02$), but were more likely to report trouble falling asleep in strange environments (3.88 and 3.59, $\underline{t} = 2.48$, $\underline{p} < .02$). Subjects reported obtaining an average of about 7.63 ($\pm$ 1.77) hours of sleep.

Place Table 7 about here

Table 7. Mean Ratings for Full Sample (N = 92)

and Nappers and Non-Nappers, on 32-Item Sleep Questionnaire

#	Item	Mean Ratings N = 92	Non-Nappers N = 39	Nappers[b] N = 18	t df = 56	t Sample 2[c] df = 103
1.	Dreams every night	2.41	2.44	2.44	0.0	
2.	Nights of dreamless sleep	3.24	3.21	3.28	.3	
3.	Perseverative thoughts at night	2.83	2.97	2.78	.9	
4.	Unable to remember dreams	2.95	3.03	2.94	.4	
5.	Wake up during night	3.52	3.46	3.50	.2	
6.	Deep sleeper	2.39	2.64	2.00	2.7***	.7
7.	Incorporate sound in dream	3.20	3.08	3.39	1.5	
8.	Nightmares	3.88	3.95	3.83	.6	
9.	Fall asleep easily	2.32	2.64	2.22	1.7*	1.7*
10.	Get up during night	3.96	3.97	3.83	.9	
11.	Talk in sleep	3.97	3.92	4.00	.3	
12.	Light sleeper	3.45	3.15	3.94	2.9***	.4
13.	Dreams of day's events	3.20	3.18	3.11	.4	
14.	Dream in color	2.86	2.84	2.61	.7	
15.	Wakes to expected sound	2.97	2.92	3.17	.7	
16.	Sleep late on Sunday	2.05	2.28	1.67	2.3	.3
17.	Catnaps	3.27	4.15	1.67	-	
18.	Oversleeps before important appointment	3.77	3.92	3.61	1.1	
19.	Difficulty falling asleep	3.43	3.23	3.56	1.4	
20.	Takes sleep medication	4.47	4.72	4.78	.4	
21.	Trouble sleeping in strange environment	3.88	3.62	4.28	3.1***	.7
22.	Likes to sleep	1.96	2.07	1.78	1.0	
23.	Can alter dream content	3.62	3.59	3.44	.5	
24.	Predecides dream content	4.14	4.10	4.06	.2	
25.	Sleep during movie, concert	4.11	4.33	3.89	2.0**	1.3
26.	Sleeps on long trip	3.13	3.41	2.78	1.9*	2.4**
27.	Awake at predetermined time	3.03	3.03	3.33	1.0	
28.	Sleep at will	3.02	3.36	2.67	2.4**	2.5**
29.	No sleep before important event	2.98	2.90	2.94	.1	
30.	Time of day work best	4.02	4.07	4.11	0.0	
32.	Hours sleep needed	7.64	7.53	7.50	.1	

*p < .10 **p < .05 ***p < .01

a. See appended questionnaire for exact wording. Named item corresponds to low score on end of scale.

b. Nappers and non-nappers defined by responses of 1,2 or 4,5 on question 17.

c. Validation sample. t-tests performed only on items discriminating groups in first sample.

Nappers and Non-Nappers. The mean incidence of napping was rated 3.22 ± .99 and 3.25 ± .96 respectively (t = .26, insignificant). In the samples of 92 and 180, 19.6 percent and 20.0 percent of the subjects reported they napped always or usually, while 42.4 and 38.3 percent reported they rarely or never napped. Similar data are available for a total of 453 students, and there are 16.3 percent and 39.9 percent falling into the napper and non-napper categories respectively.

Mean ratings on all of the questionnaire items are reported for nappers and non-nappers in Table 7, together with t-tests comparing the two groups. Only 8 of the questionnaire items significantly discriminated between the two groups. The larger sample was used to cross-validate these findings, and t-tests for the 8 significant items are also reported in Table 7. Only 3 of these items successfully discriminated between nappers and non-nappers in both samples. These items are:

9. Do you fall asleep easily ?

26. Can you go to sleep at will on a long plane trip or car trip?

28. Can you go to sleep at will?

These three items, along with the napping item, are among the most important variables defining the "ease of sleeping" factor reported above.

Correlates of Self-Reported Napping. Scores for nappers and non-nappers on the three factors for which scores were derived are presented in Table 8. The two groups of subjects do not differ on either the dreaming or insomnia factors. Nappers score consistently better (low score) on the ease of sleep factor ($p < .001$) for both samples. This result is partly spurious because the napping question loads highly on the factor, but the significant differences between the two groups on three of the questions involved in this factor indicate that the difference is not entirely a function of item overlap.

Place Table 8 about here

An interesting finding which requires further validation is the strong tendency for nappers to have higher (7.63) hypnotic susceptibility scale scores on the Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C) of Weitzenhoffer and Hilgard (1962) than the non-nappers (5.21; $\underline{t} = 4.03$, $\underline{p} < .001$). The SHSS:C scores were not available on the smaller sample. While the trends on the group-administered Harvard Group Scale of Hypnotic Susceptibility (HGSHS:A) of Shor and E. Orne (1962) are in the same direction, they are not significant for either sample. However, the correlation between HGSHS:A and SHSS:C is only around .6 and the latter scale contains items which better assess hypnotizability. This unreplicated result is consistent with our earlier findings that hypnotizability (and particularly the kinds of phenomena better represented on SHSS:C) correlated with the subjects' ability to sleep well in the laboratory and to respond rather than awaken when given suggestions during sleep (Evans et al., 1969).

Table 8. Some Correlates of Self-reported Napping

	Nappers N = 18	Non-Nappers N = 39	t	p	Nappers N = 36	Non-Nappers N = 69	t	p
Dream Factor[a]	13.44	13.49	.05	-	13.25	14.33	1.61	-
Ease of Sleeping Factor	13.22	17.95	5.80	<.001	14.44	18.31	6.90	<.001
Insomnia Factor	18.61	17.44	1.23	-	18.00	17.39	.91	-
HGSHS:A	6.88	6.36	.72	-	5.94	5.88	.11	-
SHSS:C[b]	-	-	-	-	7.63	5.21	4.03	<.001

a. Factor scores maximum 30. Low end of scale is named.

b. High score on 12-point scale indicated high susceptibility.

Summary

We have begun to explore some of the parameters of self-reported sleep behavior with the aim of learning more about those variables that might contribute to the effectiveness and quality of sleep.

Several tentative findings have emerged.

1. Responses on the sleep questionnaire are quite stable in different samples, and some parametric information about self-report sleep patterns has been obtained.

2. The questionnaire responses cluster into several distinct groups of items. Factor analyses of two samples yielded five factors which matched adequately across samples. One factor appeared to involve the ease with which individuals could fall asleep and maintain sleep in a variety of circumstances. A second factor matched well, but was difficult to interpret psychologically--apart from the fact that it was defined by many of the items concerned with dreaming. A third factor was identified as an "insomnia" dimension. A fourth factor, conceptually independent of the ease of sleep and insomnia measures, involved an inability to maintain sleep once it had been achieved. A fifth factor identified individuals who claimed that they could exert voluntary control over sleep and dream functions. A factor which emerged only in one sample may have involved long and short sleepers. Factor scores could be estimated reliably only on the first three factors.

3. Some preliminary evidence supporting the validity of the factor interpretations was obtained on the napping study summarized elsewhere in this report.

4. About 16 percent of male college students responded that they frequently or always nap, while about 40 percent reported they rarely or never nap. There were significant differences between nappers and non-nappers on the ease of falling asleep dimension, but not on the other factors. Similar significant differences occurred on three of the items loading highly on that factor (ability to fall asleep easily, ability to fall asleep in a movie or concert, and ability to fall asleep at will).

In general, the results obtained so far suggest that further validation research is warranted. It will be necessary to validate the factor interpretations by relating appropriate scores to objective indices of sleep and to performance changes as a function of sleep. This kind of data will automatically become available in the course of the regular studies being conducted as part of this program.

While it would be encouraging if these subjective patterns correlate with the relevant objective criterion measures of sleep, the usefulness of the present data does not depend on such correlations. These are the dimensions that describe an individual's report about his subjective experience of sleep, and presumably carried to an extreme, could form the basis of a patient's clinical symptomatology concerning sleep. This is merely emphasizing, for example, that the patient reporting insomnia may require treatment for his experiential insomnia regardless of the number of hours he may sleep according to EEG criteria. Nevertheless, to the extent that there is convergence between subjective and objective patterns of sleep, this line of research is clearly important in terms of understanding qualitative aspects of sleep, for selecting appropriate research samples, and for the treatment of sleep pathology.

It should now be possible to modify the sleep questionnaire, retaining only those items which define the well-matched factors, adding other items which should clarify and test the validity of the interpretation. If our interpretations are correct, in many studies we would want to eliminate those subjects with high scores on the insomnia and intermittent arousal dimensions. Those subjects who score well on the ease of sleep dimension would obviously be the most appropriate individuals for napping studies.

Proposed Studies of Self-Reported Napping Patterns

In our work on self-reported sleep patterns, we described three important and independent dimensions of subjective sleep: ease of sleeping (or control of sleep); difficulty of maintaining sleep, and insomnia. Of central importance to our overall program on sleep efficiency and the quality of sleep is the fact that the tendency to take catnaps was one of the main variables defining the control of sleep factor. Not only did nappers and non-nappers differ significantly on this dimension ($p < .001$), but, more specifically, nappers fall asleep at night more easily, tend to fall asleep on long plane or car trips, and can go to sleep at will significantly more readily than non-nappers.

At this stage of our research several hypotheses concerning napping seem to present themselves as viable directions of investigation.

1. The ability to select those subjects who are capable of taking beneficial short naps and who typically do so, will facilitate the research

program, as such subjects seem to have the desirable quality of being able to sleep on demand in the laboratory.

2. We have already documented important differences between nappers and non-nappers in what they consider to be satisfying sleep.

3. Napping seems to be a useful and beneficial way for some people to sleep efficiently when sleep is needed.

4. The ability to nap is closely related to the ease of falling asleep in a variety of unusual circumstances, as well as at night. A mechanism that may be implicated is the ability to alter one's state of consciousness easily and readily. Thus, nappers are also more able to enter hypnosis, while both of the qualities are implicated in being able to monitor the external environment efficiently while asleep (Evans et al.,1969).

5. There are as yet unconfirmed hints that at least some napping and sleep epochs may serve an appetitive or defensive function rather than a function in terms of recovery from sleep loss. It was reported above that nappers are more likely to sleep longer before an important appointment. Similarly, we have noted that nappers show a reduction in anxiety following a satisfying laboratory nap. Elsewhere we have observed that otherwise alert subjects in whom the hypnotic situation had been abruptly terminated tended to nap briefly (Orne & Evans, 1966), after spontaneously terminating the hypnotic state. Perhaps in some instances napping serves as a defense mechanism to protect the subject from stress or anxiety, instead of functioning to replace sleep or recover from fatigue. Possibly the hypnagogic period of descending Stage I, apparently perceived differently

in terms of sleep by nappers, plays a psychodynamic role in the recovery from anxiety. This notion could be partly tested by measuring anxiety levels (and associated fantasy material) following awakenings from descending Stage I and from after Stage II onset.

These several observations about the possible nature of napping can be best explored only after developing a more detailed understanding of the nap. Our preliminary survey clearly indicates that there is a wide variety of opinions regarding the length of, definition of, reasons for, and optimal conditions for napping. In an attempt to clarify some of these differences we propose to undertake a survey of self-reported napping behavior. An appropriate questionnaire is in the process of being developed and a preliminary version is available. The questionnaire will be given to several large psychology classes for pilot testing.

The questionnaire has some unusual features, and is basically divided into two sections. On the first section several relevant questions about sleep and napping patterns are included. Statistical comparisons will be made between nappers and non-nappers. The purpose of the second part is not so much comparative, as it is to survey individuals on several questions related to napping depending on their prior napping experience. We felt that it would be futile to ask a non-napper questions such as the reasons for and circumstances under which he enjoyed napping, when he found it beneficial, etc. Instead, we designed two separate sections, one to be filled out only by those who report they do sometimes nap, but an entirely different one for those who claim they rarely or never nap. By using this strategy we hope to maximize our ability to seek information that is pertinent to the particular subject's differing background experiences. By examining the frequencies of certain types of answers given separately by nappers and non-nappers, we not only hope to provide a great deal of previously unavailable information about napping, but expect to generate new productive hypotheses to guide our research on the quality and efficiency of sleep, as well as to maximize our long term ability to preselect the appropriate subject populations for the particular research questions being addressed.

COMPARISON OF DAYTIME NAPPING BETWEEN HABITUAL NAPPERS AND NON-NAPPERS

Central to our interests in napping behavior is the recognition that some individuals habitually employ naps in the course of their daily lives. They report that when their performance is impaired due to fatigue--such as while driving a long distance, preparing a report against a deadline, or seeking to solve a particularly difficult problem--they are able to pull off the road or put their head on the desk and take a nap. Following a relatively brief period, ranging from ten minutes to half an hour, these individuals report that they feel considerably better and are able to resume work with greater effectiveness.

A number of aspects of napping seem of particular interest. In a series of interviews we explored some of the parameters of napping behavior and were particularly interested to find that subjects describe naps as different from merely closing their eyes and resting, suggesting something other than simply relaxing was involved. Further, not all naps were reported to be equally effective. While habitual nappers usually felt refreshed and satisfied, occasionally a nap not only failed to serve its restorative function but left them in a somewhat worse state than before. Finally, we noted that individuals differed radically in their attitude toward naps. In interviews non-nappers often elaborated a marked aversion to taking naps. They typically reported that when tired it was essential for them to guard against falling asleep for brief periods since they felt far worse on awakening. At such times they would welcome the opportunity to sleep, but it was essential for them to sleep for a long period, such as four or more hours, in order to experience any beneficial effects.

There is compelling anecdotal evidence to indicate that napping has a beneficial effect on the performance of some individuals. Of major importance for our research goals, it would appear that one group of individuals is capable of using short periods of sleep, or sleep-like activity as an efficient and effective procedure to recover from fatigue and restore optimal mental functioning, while others seem to lack this capability. The present study seeks to address the physiological differences between the kind of sleep activity in which nappers engage, as opposed to that of non-nappers, in the hopes of helping to clarify the strikingly different attitudes of these two groups.

We were particularly impressed by the similarity in the reports describing the occasional bad nap and the typical nap report of non-nappers. Also, these interview data appeared consistent with our previous observations about the effects of delta sleep. It seemed plausible that one of the major differences between nappers and non-nappers might be that the nappers had learned to avoid falling into delta sleep while fatigued non-nappers were more likely to enter delta. Such a view is also consistent with the common observation that many older individuals learn to enjoy short naps at a time in life coinciding with a sharp drop in the amount of time spent in delta sleep.

As an initial approach to this problem, we chose to study nappers and non-nappers over a number of days in the absence of sleep deprivation in order to evaluate the nature of short naps as they are habitually employed by individuals yet without confounding the napping behavior with the effects of partial sleep deprivation or undue fatigue. Instead of equating the amount of sleep obtained during a nap, it seemed more appropriate to provide a realistic period such as would usually be available for a nap. A 30-minute period was therefore chosen during which a subject was given the opportunity to sleep to the extent that he was able to do so. Following a variety of pilot runs, five subjects--three nappers and two non-nappers--were studied in depth over a period of eight days for a total of 40 sessions. A number of measures were employed. In addition to physiological measures, subjective estimates of sleepiness and nap satisfaction were obtained and a Mood Adjective Checklist was repeatedly administered. Two measures of reaction time on awakening were used and subjects' estimates of how many minutes they had slept and how deeply asleep they were at the deepest point of their nap were recorded.

Method

Subjects

Nappers and non-nappers were selected according to both objective and subjective criteria from the laboratory staff pool. All members of the "napper" group reported liking naps and demonstrated regular napping behavior in the laboratory during work breaks. Non-nappers were selected from those individuals who reported an active dislike for naps, and who were not observed napping during breaks in the working day. The three napper and two non-napper volunteers participated in an in-depth study in which individual physiological, behavioral, and subjective measures were obtained over eight experimental sessions.

Physiological Measures

Right frontal (F4), occipital (O4), parietal (C4), and left occipital (O3) EEG were recorded with reference to the ipsilateral mastoid. Small Beckman biopotential electrodes served as transducers. Occipital EEG from the left hemisphere was filtered and recorded separately to allow a more detailed evaluation of changes in alpha frequency and density. Left and right EOG were recorded with reference to the ipsilateral mastoid using a 6-second time constant in order to evaluate the concomitance between Stage I, spindle onset and slow eye movements. Skin potential and blood volume changes were also recorded.

Subjective and Behavioral Measurements

Even with an experimental group consisting entirely of nappers, it is to be expected that there will be variation both between and within subjects with regard to the subjective effects of napping. In an attempt to quantitatively assess such subjective aspects, four parameters of subjective state were examined.

One potential influence upon napping behavior and feeling state is the subject's level of arousal. The Subjective Sleepiness Scale, a 10-point unidirectional rating scale was constructed and presented visually to the subject. His task was to indicate on the scale, which ranged from 1 ("wide awake") to 10 ("the need for sleep is overwhelming; sleep is unavoidable"), his current level of arousal.

A second aspect of subjective experience investigated was the perceived depth of sleep attained during the session. The Depth of Sleep Scale was constructed similarly to the Subjective Sleepiness Scale, and upon presentation the subject indicated sleep depth along a continuum from 1 ("wide awake") to 10 ("as deeply as I ever sleep").

Both of the above rating scales provide indirect measures of the affective component of the laboratory experience. However, in order to obtain a more direct measure, the subject was also required to rate on the Nap Satisfaction Scale his evaluation of the experience. The scale ranged from 1 ("feeling much better now than before the nap") to 10 ("feeling much worse than before the nap").

A final measure attempted to evaluate the commonplace observation that sleep in many instances seems to alter the mood of an individual. The Mood Adjective Checklist was administered both before and after each nap and difference scores calculated for each of the 11 scales.

In addition to these scale variables, the subject's estimate of the length of time actually slept during the experimental period was recorded. Time estimates had proved particularly interesting in our previous work with performance as a function of sleep replacement, and we suspected that nappers and non-nappers might differ in their accuracy of estimation.

In an attempt to obtain some objective measure of awakening, the length of time from the onset of the awakening stimulus to EEG arousal was measured. As a measure of the speed with which the subject, on being aroused from sleep, was able to perform a simple, well-learned motor task, the reaction time from onset of the awakening stimulus to picking up a telephone receiver placed on a bedside table was recorded.

Procedure*

The overall design of the experiment consisted of an initial adaptation session followed by three consecutive experimental sessions, a three-day break, and finally four additional experimental sessions conducted on consecutive days. Thus, each subject participated in a total of eight experimental sessions, with each session lasting approximately one hour.

Day 1 was designed to familiarize the subject with the experimental procedures and with the various measuring devices to be used. In addition, the subject was asked to fill out the Patterns of Sleep Questionnaire, Form L in order to provide detailed information about the subject's sleep habits and other potentially relevant variables. While Day 1 was in most respects identical to the subsequent days, it differed in that detailed explanations of the experiments and the scales, and practice in filling out the scales, were provided. The data from Day 1 were not included

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*All experimental questionnaires are available on request from the Unit for Experimental Psychiatry.

in the analysis of results.

After the initial adaptation session, a standard procedure was adopted. The subject reported to the waiting room at the appointed time, where he completed the Patterns of Sleep Questionnaire, Form S, which was designed to obtain detailed information about the previous night's sleep. The Mood Adjective Checklist was then administered, and the subject conducted to the experimental room by the experimenter.

The experiments were carried out in a light-proof, sound-attenuated room, containing a comfortable bed, a night-table with microphone and telephone, and the necessary equipment for attaching recording devices. All recording equipment was located in a separate control room. On arrival in the experimental chamber, the first Subjective Sleepiness Scale was administered. Transducers were then attached and the Subjective Sleepiness Scale administered again. The experimenter then left the room, turned out the lights in the experimental chamber, tested the equipment, and told the subject to begin the nap. Precisely 30 minutes later, regardless of intervening events, the subject was gradually awakened by means of soft, pleasant music 6 dB above ambient noise level. While it had originally been hoped that an independent estimate of sleep depth could be obtained by increasing the intensity of the music in 3 dB steps, all subjects awakened to the first intensity level.

The latency of EEG arousal to the wakening stimulus was recorded. As soon as the subject picked up the telephone, a pre-arranged signal that the subject had wakened, the experimenter said, "I'll be right in," turned on the lights and entered the room.

Immediately upon entering the room, and while the subject was still in bed, the Depth of Sleep Scale, the Nap Satisfaction Scale, and a third Subjective Sleepiness Scale were administered, and the subject's estimate of how long he had slept obtained. Electrodes were then removed, the Subjective Sleepiness Scale administered again, and the Mood Adjective Checklist completed.

While no formal post-experimental interview was conducted, the subjects were encouraged to comment upon their experiences while the electrodes were being removed, and typically discussed the day's experiment informally with another staff member.

Results

Electrophysiological Characteristics of the Nap

The working hypothesis that nappers should sleep more during the 30-minute experimental period than non-nappers was supported. Table 9 shows the mean time in each sleep state for the two groups of subjects. Nappers slept significantly longer than non-nappers, with the difference a function primarily of Stage II sleep. No significant differences in latency to first spindle or time in Stage I were observed.

Place Table 9 about here

Table 9. Electrophysiological Characteristics of the Naps of Nappers and Non-Nappers

Variable	Nappers		Non-Nappers		$p<$ *
	Mean	S.D.	Mean	S.D.	
Total sleep time (minutes)	19.45	6.21	12.00	7.32	.01
Time in Stage I	8.24	4.53	6.45	3.84	NS
Time in Stage II	10.30	6.33	5.55	4.92	.02
Time in Stage III	0.71	1.45	0	0	**
Time in Stage IV	0.20	0.62	0	0	**
Latency to first spindle	12.67	8.47	17.45	8.69	NS

*two-tailed t-tests for independent groups

**insufficient data for statistical test

The results of our previous experiments suggested that delta sleep during naps not only has a deleterious effect on performance but also adversely affects the subject's satisfaction with the nap. If this is in fact the case, the aversion to naps usually reported by non-nappers might be due to a tendency for these subjects to have more delta during nap periods than is experienced by persons who like to nap. While we had hoped to test this hypothesis in the present experiment, insufficient delta sleep occurred for a valid test to be made. Only 5 of the 40 naps contained delta sleep, and in only 2 of these naps was the delta well-consolidated Stage IV sleep. All naps containing delta sleep were obtained from nappers. Since, for the non-nappers, mean sleep time was only 12 minutes, and no nap exceeded 15 minutes of postspindle sleep, the results could reflect sleep time difference, rather than real differences in the amount of delta to be expected from nappers and non-nappers. No test of the hypothesis was therefore possible.

Our original assumptions would also imply that, for nappers, a nap containing well-consolidated delta sleep would be perceived as less satisfying than a nap which did not contain delta sleep. Again, the paucity of well-consolidated delta sleep within the time restrictions of the present experiment made it impossible to test the hypothesis.

Though it was not possible to adequately test the delta hypothesis in the present experiment, the five delta naps did provide an opportunity to determine whether the Nap Satisfaction Scale accurately reflected the subjective changes which had been reported by subjects in the preliminary pilot experiment. While the scale did seem to measure some aspects of nap satisfaction, there were striking differences between Nap Satisfaction Scale ratings and the postexperimental comments made by subjects, indicating that, particularly for nappers, the scale tapped something other than what was intended. It is difficult to avoid communicating the investigator's interest in sleep in this kind of study. Apparently subjects, particularly nappers, interpret falling asleep quickly and deeply as success in the experimental situation, and therefore naps tended to be rated as satisfying if they were deep--even when the nap had negative aftereffects (the correlation between the Nap Satisfaction Scale and the Depth of Sleep Scale was .47). In several instances where delta sleep was present the naps were rated as satisfying though subjects subsequently reported that they felt far worse after this particular nap than before falling asleep. In our further work we will seek to develop experimental procedures which are less likely to be confounded by subjects' wishes to succeed in the experiment and to comply with what they believe is expected of them.

Psychological Characteristics of the Nap

One of our major interests in conducting the present study was in determining the effects of brief naps on the subjective well-being of the subject. To this end we were particularly interested in investigating the psychological effects of the nap for the subjects who liked to nap, and regularly did so, in contrast to the effects for those who did not like to nap. Four approaches were used in considering such psychological variables:

changes in sleepiness, depth of sleep and satisfaction with the nap as reported by the subject, and changes in mood as measured by the Mood Adjective Checklist.

Changes in subjective sleepiness. The Subjective Sleepiness Scale was presented four times during each experimental session: once at the beginning of the session (SSS-1), once after the electrodes had been attached (SSS-2), again at the end of the 30-minute nap period (SSS-3), and finally at the end of the session, after the electrodes had been removed (SSS-4). Figure 1 presents the scale scores for each of these presentations for the sample.

Place Figure 1 about here

While absolute scores on the Subjective Sleepiness Scale did not differentiate nappers from non-nappers, the changes in sleepiness from one presentation of the scale to another were highly significant. The data are summarized in Table 10.

Place Table 10 about here

Nappers showed a significant decrease in sleepiness as a function of the nap, whether the change was measured from the beginning of the experimental session ($t = 2.15$, $p < .05$) or the beginning of the nap period

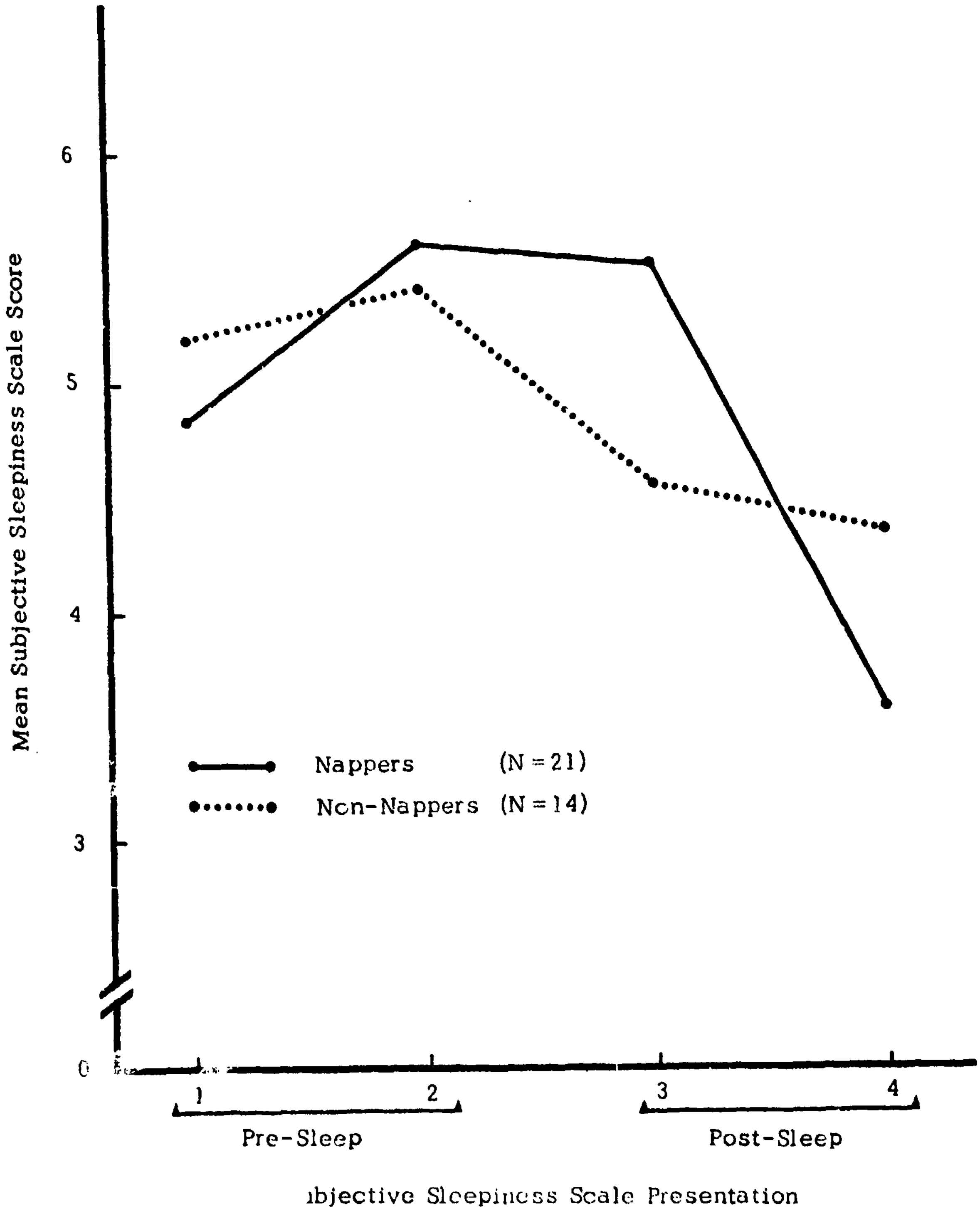


Figure 1. Subjective Sleepiness Scale ratings for nappers and non-nappers pre- and post-sleep.

Table 10. Changes in Subjective Sleepiness Scale for Nappers and Non-Nappers

Change Scores	Nappers			Non-Nappers			Nappers vs. Non-Nappers	
	Mean	S.D.	t^1	Mean	S.D.	t^1	t^2	$p<^3$
SSS2-SSS1	0.76	1.19	2.86**	0.21	0.56	1.38	1.84	.10
SSS3-SSS1	0.67	2.53	1.18	0.64	2.58	0.90	1.48	NS
SSS2-SSS3	0.10	1.92	.23	1.57	2.24	2.62*	2.02	.10
SSS3-SSS4	1.86	1.52	5.46***	0.64	2.09	0.52	1.88	.10
SSS2-SSS4	1.95	2.06	4.24***	1.07	2.71	1.42	1.03	NS
SSS1-SSS4	1.19	2.48	2.15*	0.86	2.90	1.07	0.35	NS

*$p < .05$ **$p < .01$ ***$p < .001$

1. Paired comparisons t-tests
2. Independent group t-tests
3. All tests two-tailed

($t = 4.24$, $p < .001$). In contrast, the non-nappers showed no significant change from pre- to post-nap measures.

As a group, nappers showed increased sleepiness from the beginning of the experimental period to the start of the nap period ($p < .01$). The non-nappers, on the other hand showed no consistent pattern of change between SSS-1 and SSS-2, either individually or as a group.

The decrease in sleepiness from the end of the nap period to the end of the experimental session was significant for the nappers as a group ($p < .001$), and also for each individual napper ($p = .008$, .031, and .016). Nappers who were asleep at the end of the napping period showed essentially the same pattern as those who were awake, and no correlation was found between length of time awake and final Subjective Sleepiness Scale score for those subjects who awakened spontaneously. No significant change between SSS-3 and SSS-4 was observed for the non-nappers, either individually or as a group. However, a significant correlation ($r = -.75$, $p < .005$) was observed between length of time awake at the end of the nap and the final Subjective Sleepiness Scale score for those non-nappers who awakened spontaneously.

<u>Depth of sleep</u>. Nappers and non-nappers appear to be using the same standards in judging their subjective depth of sleep. Mean ratings for naps in which Stage I was the deepest stage reached were 3.0 for both nappers and non-nappers. For Stage II naps, the mean ratings were 5.3 for nappers and 5.5 for non-nappers. Such an analysis would not be extended to Stages III and IV, since no such naps existed for the non-nappers.

There was no significant difference in the subjective depth of sleep reports for the nappers and the non-nappers. However, the relationships between depth of sleep and other variables differed markedly for the two groups of subjects. For example, when data are analyzed by sessions, time in Stage I was significantly negatively correlated with depth of sleep for nappers ($r = -.460$, $p < .025$), and significantly positively correlated for non-nappers ($r = .471$, $p < .05$); this suggests that the more Stage I a napper had, the less deeply he felt he had slept, and conversely, the more Stage I a non-napper had, the more deeply he felt he had slept.

Of major interest was the question of whether nappers and non-nappers were differentially affected in their judgment of sleep depth by whether they were awake at the end of the nap. Pilot studies had indicated that nappers usually judged depth rather accurately, and independently of the length of time they were awake before making the judgment, while non-nappers tended to judge as less deep those naps in which they were awake at the end of the allotted napping period. Essentially the same relationship was found in the present study. Mean Depth of Sleep Scale scores for nappers asleep at the end of the period was 5.60 and for nappers awake at the end, 5.67 ($t = .08$). For non-nappers, those asleep at the end reported a mean Depth of Sleep Scale score of 6.25 and those awake at the end a mean of 4.5 ($t = 3.54$, $p < .01$). These results are, of course, confounded by the depth of sleep actually achieved during the napping period. For this reason, only those non-nappers who achieved Stage II sleep were used in a re-analysis of the data. The difference between Depth of Sleep Scale Scores for non-nappers asleep at the end of the run and those awake at the end of the run was still significant ($t = 2.33$, $p < .05$).

We expected that, if the subject was deeply asleep, we would observe a longer time from onset of the awakening music to EEG arousal, and also a longer time for onset of the music to picking up the telephone. Since we did not expect these variables to differentiate nappers from non-nappers, the results were rather surprising. For the non-nappers, there was a significant correlation ($r = .49$) between the Depth of Sleep Scale and time to EEG arousal; no such correlation was observed for the nappers. For the nappers, however, there was a significant correlation between reported depth of sleep and time to pick up the telephone ($r = .46$), and no such relationship was obtained for the non-nappers. Since the non-nappers were more likely to be awake at the end of the napping period, and since this would be expected to affect reaction time, partial correlations were computed holding the length of time awake at the end of the nap constant. The resulting correlations did not differ from those reported above.

<u>Nap satisfaction</u>. While there was no difference between nappers and non-nappers on the Nap Satisfaction Scale, the variables which predicted whether a subject would be satisfied by a nap were different for the two groups. The only variable which reliably predicted nap satisfaction for the nappers was the subjective depth of sleep obtained. The more deeply they thought they slept, the more satisfied they were with the nap ($r = .47$, $p < .025$). They were not influenced in their judgment of nap satisfaction

by their state of sleepiness before or after the nap, or by their changes in sleepiness during the experimental session.

Non-nappers, on the other hand, were more satisfied with the nap if they were sleepy to begin with ($\underline{r}$ = .616), sleepy after the electrodes were attached ($\underline{r}$ = .688), and less sleepy at the end of the run ($\underline{r}$ = .63). The more their sleepiness decreased as a function of the nap, the more satisfied they were with the experience ($\underline{r}$ = .79).

Mood changes. Mean scale scores for the Mood Adjective Checklist are presented in Table 11. Both before and after the nap, nappers showed more fatigue than non-nappers, and non-nappers rated themselves higher on surgency, vigor, skepticism, and egotism than the nappers. While nappers and non-nappers did not differ in anxiety before the nap, nappers were significantly less anxious after the nap. No differences in elation were found before the nap, but the nappers were significantly more elated afterwards. These differences are a function of changes in the nappers, rather than changes in the non-nappers. Thus, nappers had considerably more anxiety before than after the nap, and significantly more elation after than before the nap.

Place Table 11 about here

Change scores for anxiety, surgency, elation, concentration, fatigue, and vigor were examined for relationships with other variables. The results are presented in Table 12. No relationship was found for either group

Table 11. Mean Scores on Mood Adjective Checklist

Scale	Nappers				Non-Nappers			
	Pre		Post		Pre		Post	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Aggression	.62	1.61	.21	.83	1.44	2.16	.50	1.37
Anxiety	.75	1.22	0	0	1.19	1.76	.88	1.20
Surgency	.25	.90	.29	.62	2.88	2.53	2.31	2.41
Elation	.08	.41	.88	1.39	.19	.54	.19	.54
Concentration	2.12	2.42	1.58	2.30	1.50	1.75	1.25	1.39
Fatigue	4.00	3.06	4.08	2.93	1.50	1.90	1.88	2.45
Vigor	.75	1.70	.88	1.83	2.94	2.77	2.50	2.00
Social Affection	.29	.55	.46	.66	1.19	1.94	.88	2.06
Sadness	.04	.20	.17	.82	.75	1.57	.50	1.37
Skepticism	.25	.61	.08	.41	2.00	1.75	1.25	1.29
Egotism	0	0	0	0	1.38	1.96	.81	1.47

between nap satisfaction scores, changes in sleepiness or depth of sleep and anxiety or concentration. Nappers showed no significant relationship between nap satisfaction or depth of sleep and any of the change scores; change in sleepiness was greater in naps associated with greater decrease in fatigue and greater increase in elation. For non-nappers, greater nap satisfaction and greater change in sleepiness were associated with naps in which there was a greater increase in surgency and vigor and a greater decrease in fatigue.

Place Table 12 about here

Unusual Sleep Patterns During the Nap

As has already been noted, there was a very low level of delta activity in the present study. One possible reason was an unusually high tendency for subjects to show systematic shifts between waking, Stage I, and Stage II. This appeared to be a truncated form of the usual sleep cycle, much shorter both in time and in the depth of sleep achieved. Instead of continuing from Stage II to the development of slow wave sleep, the subjects tended to wake briefly and repeat the cycle. This tendency was noted both in nappers and in non-nappers, though it was more clear-cut in the former. This difference, however, is likely to be related to the greater amount of Stage I and Stage II sleep found in the nappers.

We had not previously noticed the unusual kind of sleep cycling that characterized these naps. One possible explanation was related to

Table 12. Correlations between Changes in Mood and Subjective Nap Evaluations

MACL Scale	Nap Satisfaction			Change in Sleepiness			Depth of Sleep		
	Nappers	Non-Nappers	Entire Sample	Nappers	Non-Nappers	Entire Sample	Nappers	Non-Nappers	Entire Sample
Anxiety	+.221	+.400	+.267	+.037	-.388	-.144	-.139	+.149	-.040
Surgency	-.124	+.506*	+.243	-.234	-.541**	-.447***	+.151	+.376	+.166
Elation	+.066	+.135	+.144	+.372*	-.300	+.155	-.043	+.407	-.053
Concentration	+.146	+.173	+.136	+.140	-.391	-.026	-.239	+.062	-.168
Fatigue	+.049	-.716**	-.225	+.597****	+.935****	+.730****	-.013	-.232	-.073
Vigor	-.089	+.797**	+.299*	-.187	-.923****	-.580****	-.052	+.515*	+.123

* $p < .05$

** $p < .025$

*** $p < .01$

**** $p < .005$

the subjects' expectation that they would be awakened at the end of 30 minutes. Data from a previously reported study were used to examine this hypothesis. During the previous study naps of two to three hours' duration were examined. However, for some but not all of the sessions subjects knew that they would be awakened shortly after going to sleep while in others no such expectation was present. Sixteen sleep sessions were used for the analysis. For eight of these sessions subjects expected to be awakened shortly after going to sleep while for the other eight they did not. The frequency of cycling in these two groups of naps during the first 30 minutes of the sleep period was then tabulated. Six of the eight runs in which awakening was expected 5 to 20 minutes after sleep onset showed the cycling effect observed in the present experiment. Of the subjects who did not expect to be awakened, however, none showed such cycling ($\underline{p} < .01$).

It appears that the expectation of being awakened shortly after the beginning of a nap results in an unusual pattern of sleep activity probably associated with more active monitoring of the environment and reflected in continual cycling between wakefulness, Stage I and Stage II. It would appear that some individuals are capable of drastically modifying their sleep pattern if they expect to sleep only short periods. (Analogous changes may well be associated with selective monitoring as in the "mother's cry" phenomenon.) This modified form of sleep activity may serve the purpose of preventing some of the dramatic performance decrement seen with arousal from profound sleep without necessarily preventing some of the beneficial effects of sleep. In future work we hope to explore the different effects on recovery from fatigue associated with the different kinds of sleep activity.

The Subjective Interpretation of Stage I Sleep

It has already been pointed out that time in Stage I sleep was negatively correlated with the Depth of Sleep Scale for nappers and positively correlated for non-nappers. This finding suggested that nappers and non-nappers might interpret Stage I sleep differently. To test this hypothesis, subjective time estimates were examined for nappers and non-nappers. The correlation between time in Stage I and subjective time estimate was significant and negative for nappers, and significant and positive for non-nappers (-.608 and + .767 respectively), providing preliminary support for the hypothesis.

While nappers and non-nappers differed in their total amount of sleep, no significant differences were found for amount of time spent in Stage I, percent Stage I, or number of epochs of Stage I. Nappers did not show a different distribution of Stage I sleep than non-nappers. Both groups showed slightly more Stage I activity before the first spindle than after, but no group differences were found.

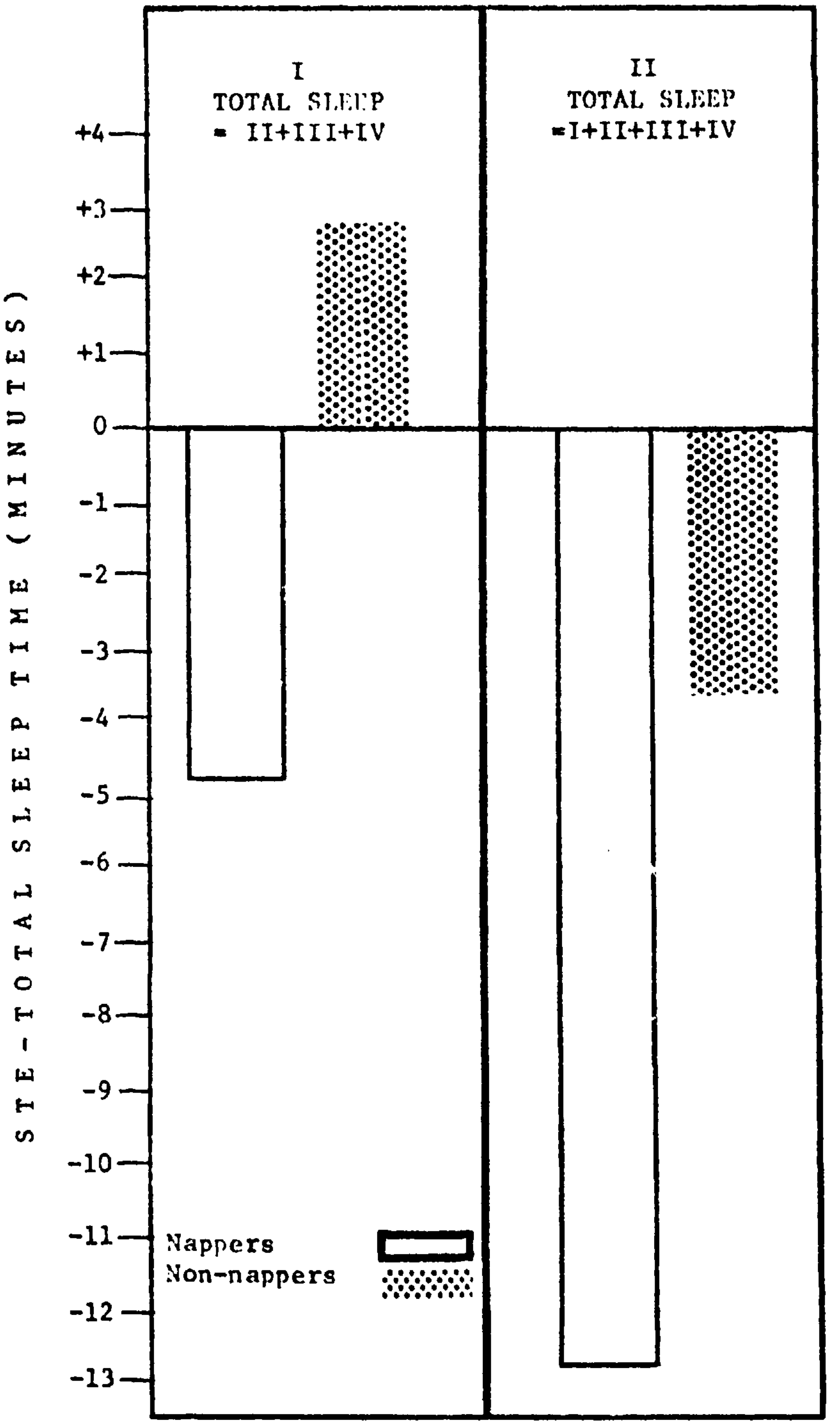
However, while for both the nappers and the non-nappers Stage I sleep parameters were similar, the accuracy of subjective time estimates were strikingly different between the groups--depending upon whether or not Stage I sleep was included in the determination of actual EEG sleep time. This is seen in Figure 2. When total sleep was defined as Stages II, III, and IV, nappers <u>under</u>-estimated the length of the nap by approximately

4.8 minutes, while non-nappers over-estimated by 2.8 minutes ($t = 4.14$, $p < .001$). When Stage I sleep was included in the definition of total sleep time however, both groups under-estimated how long they had slept, nappers by 12.8 minutes and non-nappers by 3.6 minutes. Again, the difference was significant ($t = 4.42$, $p < .001$). Under both conditions, nappers differed significantly from non-nappers, and between conditions, both groups showed a significant change. There was, however, no significant difference between the accuracy of nappers when Stage I was excluded and the accuracy of non-nappers when Stage I was included.

Place Figure 2 about here

Finally, such differences might have been due to a tendency of subjects, in reporting how long they slept, to round off to five-minute units (for example 5 minutes, 10 minutes, 15 minutes, etc.). An analysis was therefore done of the actual sleep time rounded to the nearest five-minute block. While this rounding did lower significance levels, the effect was still present and still significant.

Further, since nappers and non-nappers differed in their mean time asleep, the possibility was examined that the manner in which Stage I sleep is experienced might be a function of nap length. The hypothesis was not supported. Naps of equal length were selected for nappers and non-nappers. In cases where selection of matched length naps could either support or go against the hypothesis that nappers and non-nappers perceive



	t
Nappers I vs II	8.04[a]
Non-nappers I vs II	6.26[a]
Nappers vs Non-nappers I	-4.14[a]
Nappers vs Non-nappers II	-4.42[a]
Nappers I vs Non-nappers II	0.243

[a] $p < .001$

Figure 2. Accuracy of sleep time estimates for nappers and non-nappers as a function of Stage I sleep.

Stage I differently, the nap which went against the hypothesis was, as a more stringent test, always selected. The effect of this manipulation can be seen in the second panel of Figure 2. No difference was found between the analysis with matched and unmatched nap lengths. Though these findings will need to be validated in larger samples, it would appear that subjects who habitually nap experience Stage I sleep differently. Nappers do not seem to consider Stage I sleep as sleep, while individuals who do not habitually nap experience Stage I as full sleep.

Discussion

This study provides some empirical support for the differences in sleep patterns reported by nappers and non-nappers. Thus, nappers slept significantly more during the half-hour periods that were provided for this purpose. We interpreted other differences cautiously lest these turn out to be a function of differences in the amount of sleep obtained. Nonetheless, even this preliminary study suggests some interesting and important qualities of napping behavior.

First, we noted that there is a characteristic form of sleep pattern associated with the expectation of being awakened after a relatively brief period of time. This consisted of cycling between wakefulness and Stage II with a tendency never to go beyond Stage II. This tendency was more obvious among the napping subjects, probably because of the greater amount of sleep they had obtained. Partly because of the paucity of sleep as well as the tendency to cycle only to Stage II we did not obtain any delta sleep in the non-nappers, somewhat contrary to our expectations. Only five episodes of delta were observed, and these occurred exclusively among the nappers. When they did occur, they tended to be associated with dysphoric comments about the experience though the social psychological situation of the experiment and the design of the scale prevented these experiences from being reflected by changes on the Nap Satisfaction Scale. Care is being taken to improve this subjective measure and to provide better opportunities for subjects to report their affective responses to the nap.

The initial hypothesis concerning the significance of delta sleep in napping behavior could not be tested. In retrospect, it is not surprising that the individuals who do not normally choose to nap, when asked to do so, showed relatively little sleep. The reports of these individuals are that they must guard against falling asleep when they are tired lest they awake feeling worse than previously. Future work designed to yield a more reasonable test of the hypothesis will require that subjects have considerable fatigue at the time they are asked to nap.

The ability of subjects, both nappers and non-nappers, to truncate their sleep cycles is, we believe, a novel finding and fits nicely with our previous observation concerning the deleterious effect of delta sleep during short naps. This type of cycling is seen relatively frequently in night sleep as subjects approach their normal waking time and is probably associated with a more careful monitoring of the external environment. The relative effectiveness of this kind of sleep activity on recovery from fatigue as opposed to cycling to deeper stages may prove to be of central importance to any program designed to help individuals learn to use short periods of sleep as efficiently as possible.

The subjective effects of naps differ markedly between nappers and non-nappers. Nappers showed decreased sleepiness as a function of naps while non-nappers did not; however, nappers seem to have more difficulty in recovering from the negative disorienting effects of sleep. They seem to require a short period of activity in order to obtain the full benefit of the nap. Non-nappers recovered from whatever negative subjective effects of sleep were present very quickly, often before getting up; however, this difference is, at least in part, a function of the tendency for non-nappers to have been awake prior to the signal for awakening. The relationship between subjective measures and variables such as reaction time and mood changes suggests that non-nappers judge a nap more in terms of increased efficiency, greater loss of fatigue, and increase of vigor and decreased sleepiness, while nappers respond more to the affective components such as decreases in anxiety and increases in elation, despite the fact that overall they show a significantly greater decrease in sleepiness as a function of the nap.

It seems likely, however, that nappers enjoy naps not only because they result in increased vigor or efficiency, as we had expected, but also because napping permits them to withdraw from the world, somehow augmenting their subjective feelings of well-being and decreasing their feelings of anxiety. It still remains to be determined, however, why non-nappers do not like to take naps.

The data clearly suggest that nappers do not interpret Stage I activity as sleep, while non-nappers do. Together with the results suggesting that nappers and non-nappers have quite different affective experiences during the napping period, this finding leads us to speculate that the experiential difference is due partly to quality of mentation during the Stage I hypnagogic period. It may well be that nappers belong to the group described by Foulkes, Spear, and Symonds (1966) who engage in hypnagogic mentation, and this is clearly perceived by them as different from sleep.

The present study suggests that napping, in non-sleep-deprived individuals at least, may serve functions other than sleep substitution. Napping, like eating, may be carried out as appetitive behavior associated with positive affective experiences. In seeking to understand this form of behavior, it would seem essential to consider not only the distinction between nappers and non-nappers but also the difference between the sleep-deprived, fatigued individuals as opposed to those who seek to sleep for pleasure.

A clear recognition of the multiple functions of napping behavior, depending upon the individual's past history on the one hand, and his need for sleep on the other, will be crucial in our attempts to identify the manner in which short periods of sleep can serve to facilitate recovery from fatigue. The possibility that an improvement in performance following napping may be mediated by changes in subjective fatigue rather than modifying what might be conceived of as a physiological unit of cognitive performance needs to be considered. The present investigations again underline the importance of careful attention to both the subjective consequences of napping on the one hand, and the state of the organism at the time the nap occurs on the other, in any effort to get at the functional significance of this category of behaviors.

THE EFFECTS OF SLEEP LOSS AND THE RECOVERY OF TASK PERFORMANCE

A number of previous studies have documented the deleterious effects of sleep deprivation on performance (e.g., Naitoh, 1969). The focus of such studies has been on the progressive deterioration of functioning as the individual is required to remain awake for longer and longer periods. While such an approach has documented the deleterious effects of sleep loss and its associated fatigue, it is clear that circadian rhythms and motivation are also such potent factors in modifying performance that, with moderate levels of deprivation, these could easily serve to obscure detrimental effects, especially on short term performance. For these reasons we have sought to approach the question of how short periods of sleep may reduce fatigue by investigating the recovery function in relation to performance. Such an approach obviates the need for continuous monitoring during sleep deprivation and can help minimize circadian effects, permitting us to place more emphasis on the physiological nature of the sleep period in relation to its possible beneficial effects on performance. Our strategy thus has been to bring subjects to the laboratory while fatigued and see how their depressed performance may be benefited by short periods of sleep.

The purpose of the study to be described is to examine the extent to which a two-hour nap leads to recovery of cognitive functions after moderate sleep deprivation. In particular, we were concerned with determining the effects of different kinds of sleep components and changes in the degree of activation on the various dependent measures.

Of particular interest are the changes in subjective experience associated with napping. Thus we were concerned with alterations in mood, the subjective feeling of fatigue, and the perception of having slept, both as dependent variables in their own right and also as indices which might serve as predictors of performance measures.

The Development of Appropriate Performance Criteria

The most important single research problem encountered in designing this study was related to the performance measures to be employed. Most investigators have concluded that individuals who have been sleep-deprived even for considerable periods are usually able to marshal their resources sufficiently to perform for short periods of time at a level close to their normal undeprived performance. The most successful attempts to document the effects of sleep deprivation have involved either very long periods with no sleep (Williams, Lubin, & Goodnow, 1959), or lengthy performance tasks such as those typically encountered in a work situation (Alluisi, 1964), or by the use of a continuous vigilance situation (Wilkinson, 1968). Despite the fact that even moderate sleep deprivation has clear and unambiguous subjective consequences for the individual, decrements induced by moderate deprivation on short-term performance have been difficult to document.

An encouraging exception has been a study by Williams and Lubin (1967) who were able to demonstrate that subjects deprived of sleep for only 26 hours show a performance decrement when faced with a task requiring the short-term maintenance of attention and motivation, so long as the task is sufficiently demanding in terms of cognitive ability. Performance on the task does not break down completely but tends to become sporadic, with the most powerful dependent variable being the omission of items. Such studies suggest that it might be possible in the laboratory to document performance effects which parallel the subjective effect of sleep deprivation even when the amount of sleep loss is relatively small (i.e., three to five hours less sleep than the subject is accustomed to). Previous research indicates such a task would require (a.) a strong cognitive load (Williams & Lubin, 1967), and (b.) experimenter pacing (Naitoh, 1969). Further, for theoretical reasons we felt that a task which failed to provide feedback to the subject concerning the adequacy of his own performance might prove particularly useful in making it difficult for him to accurately allocate his resources when fatigued.

Previously we have reported results of an experiment in which moderately sleep-deprived subjects were required to perform the Descending Subtraction Task and in which performance improved following brief naps. The Descending Subtraction Task requires the subject to keep in mind and manipulate several items of information simultaneously, and meets the first of the criteria listed above in that it provides a strong cognitive load. The focus of that study was primarily on the effect of arousal from delta sleep as opposed to arousal from REM sleep, and insufficient information was available to evaluate the effect of sleep deprivation *per se* on task performance. While this procedure continues to look promising and we have continued to employ it in the present experiment, we also sought to find another task which was experimenter-paced, which placed a considerable cognitive load on the individual, and which did not provide feedback about task performance, in the hopes that it might be even more effective in reflecting moderate degrees of fatigue.

In the context of other research, we have been working on the task of asking subjects to produce random numbers. Though this task sounds simple, it demands that the subject keep in mind the numbers he has generated in the past--in order to avoid using any given number more than another or repeating a number too frequently. Research reviewed by Wagenaar (1972) has shown that the random number task has the potential of reflecting alterations in consciousness, but the current state of analysis was insensitive and required subjects to produce a large number of digits for analysis. Our laboratory has developed a technique for determining randomness adapted from Tulving's (1962) work on the organizational strategies of free recall, and developed a computer program for scoring the randomness of the subject's output of digits in order to make this a practical procedure. As few as 100 digits yield a reasonably reliable randomness score. Another important aspect of this task is that it is well nigh impossible for either the subject or the experimenter to detect the relative changes in randomness which occur. Thus, within a broad range of performance there is no feedback to the subject concerning how well he is doing. Finally, it is possible to pace this procedure externally by insisting that subjects produce a number each second in time with a metronome. Pilot studies had indicated that while the Random Number Generation Task was relatively insensitive when subject-paced, it varied with sleep deprivation when experimenter-paced.

Although the Random Number Task itself seemed promising, we wished to add an additional cognitive load to the performance on the task. After experimenting with a variety of procedures, we selected the two-hand coordinator where performance can readily be quantified and which subjects can learn to perform with no errors even when fatigued. Subjects were trained to the criterion of near-perfect performance and were then required to generate random numbers while simultaneously maintaining perfect performance on the two-hand coordinator. The background task of maintaining such perfect performance on the two-hand coordinator requires continuous monitoring by the subject and apparently serves to make the Random Number Task a far more sensitive measure of cognitive capability. We hypothesized that, when an individual is fatigued, more of his resources would be involved in maintaining perfect performance on the two-hand coordinator and thus less would be available for the generation of random numbers. This hypothesis derived support when the results of asking subjects to generate random numbers while learning to perform the two-hand coordinator task were examined (Graham & Evans, 1973). Randomness was depressed as compared to baseline when subjects first began to learn the two-hand coordinator task. However, as learning proceeded, the two-hand coordinator performance improved and randomness increased. When the two-hand coordinator task had been learned so well that it could be performed automatically and with no real effort, random number generation returned to baseline.

The results of Williams and Lubin (1967) and of Graham and Evans (1973) in conjunction with a series of pilot studies suggested that the combination of the two-hand coordinator and random number generation might well provide the kind of intellectual challenge which exceeds the capabilities of the fatigued individual in the sense that he performs less than optimally even when motivated to maintain performance.

Both the Descending Subtraction Task and the Combined Random Number Generation with the Two-Hand Coordinator task were felt to show considerable promise as performance measures which are sensitive to moderate amounts of fatigue and which might reflect the recovery of cognitive functions following short periods of sleep. However, we were also concerned lest subjects might surmise our expectations that their performance would suffer due to sleep loss and fatigue and recover as a function of sleep. Since much past research in our laboratory has shown that subjects' expectations often confirm their behaviors to their perception of the investigator's hypothesis, two additional tasks were included to help estimate possible demand characteristics in the experimental situation. We selected two performance measures which past work had demonstrated to be insensitive to the effects of short-term sleep loss but which had face validity equal to that of the experimental tasks. These two procedures, the Serial Addition Task based on the work of Williams and Lubin (1967) and the Digit-Symbol Subtest of Wechsler-Bellevue were used. We hypothesized that decrements resulting from subtle cues or expectations would be reflected by similar changes on all four performance measures, whereas the specific effects of fatigue and recovery from these effects should be reflected only on the Descending Subtraction and the Random Number procedures but not on the other two tasks.

In addition to the four principal performance measures which have been discussed above, EEG reaction time and the time to answer the telephone on arousal were also recorded. In essence then, this study attempts to relate the nature of the physiological changes associated with napping to the domain of performance on the one hand and to the domain of subjective experience on the other.

Method

Subjects

Six volunteers between the ages of 16 and 25, none of whom had previously taken part in psychophysiological experiments, participated in all five sessions of the present study.

Performance Tasks

A number of performance tasks were employed; some tasks were predicted to vary with sleep deprivation and the recovery of sleep, others were designed to assess the effects of the demand characteristics of the experimental situation, and the remainder to elucidate the relationship between subjective state and psychophysiological state.

Experimental tasks. The Two-Hand Coordinator Task involves tracking a one-inch diameter target which moves in an irregular, circular pattern at one revolution per minute. Tracking is accomplished by simultaneously rotating two handles, one of which moves the tracker horizontally, and one of which moves it vertically. Total time for one trial is 120 seconds, or two complete revolutions. Feedback is provided to the subject both by visual inspection and by a clearly audible click which occurs when contact between the tracker and the target is broken. Task performance analysis is based on the number of seconds on target per trial.

The generation of random numbers as a measure of the deployment of attention is based on modifications of the procedures described by Wagenaar (1972). The concept of randomness is first explained to the subject, and he is then asked to generate a series of random numbers, using only the numbers from one to ten inclusive for a five-minute period. We had previously done pilot work in the sleep replacement paradigm using this task, and found it inadequate; in that experiment, however, the subject was allowed to set his own pace so that work curves could be established. In the present experiment the subject was instructed to produce one number per second, in time with the metronome. Pilot studies suggested that such a change in procedure would render the task sensitive to the effects of moderate sleep deprivation and replacement.

Analysis of random number generation provides two scores which, although correlated, measure slightly different aspects of performance. The subjective organization score measures the frequency with which each number follows every other number. The digit use score is analogous to chi-square and measures whether each digit was used an equal number of times.

To the extent that sleep deprivation interferes with the ability of the subject to maintain attention and motivation, it would be expected that, even though performance on the Two-Hand Coordinator was not changed, performance on the Random Number Task would be impaired. Such an outcome is even more likely in the present experiment since instructions stressed the need to maintain perfect Two-Hand Coordinator performance, and the Random Number Generation Task provides no feedback to the subject (or, in fact, to the experimenter) about his performance.

We previously used the Descending Subtraction Task in evaluating the effects of sleep replacement and of sudden awakening on task performance. Our work with this task continued in the present experiment. The Descending Subtraction Task required the subject to simultaneously keep in mind and manipulate items of information. The subject is presented with a large number, such as 485. He must then subtract 9 from that number, then subtract 8 from the remainder, then 7 and so on until he subtracts 2, after which he begins again with 9 and repeats the sequence until told to stop. It is necessary for the subject to keep in mind not only the base number but also how far he has progressed in the descending order of subtractors. Losing track of either results in error. Several measures have been developed based on this task. The average time to produce each number, independent of errors, the percent errors produced, the number of items before the first uncorrected error occurs, and a decrement score based on the difference between pre-sleep and post-sleep performance, divided by the pre-sleep performance, were reported in the previous progress report and have been used in the present experiment. In addition, a reliable way of scoring the types of errors produced by the subject has now been developed, allowing us to determine whether the proportion of errors attributable to loss of either the base number or the subtractor increases as a function of sleep loss, as compared with the proportion of arithmetical errors.

Control tasks. The preceding tasks were designed to tap aspects of performance which we felt would be sensitive to moderate sleep loss and its recovery. There is always the possibility, however, that subjects, having become aware of the experimental hypotheses, might be less motivated to perform well on the pre-sleep tasks after deprivation. To assess the effect of these demand characteristics, the Speeded Addition Task was included in the test battery. Speeded addition has been shown to be sensitive to sleep loss of 26 hours or more but to be insensitive to lesser amounts of sleep loss (Williams & Lubin, 1967). It consequently provides a task with clear face validity which is insensitive to the effects of the experimental manipulation. Changes in performance on the Speeded Addition Task would therefore be interpreted as an indication that performance of subjects on the other tasks might have been affected by the motivational demand characteristics of the situation. The three-minute task consists of a series of pairs of one-digit numbers. The subject's task is to add the two numbers of the pair together and write down the answer on a form provided for the purpose. In the present experiment tape-recorded pairs of numbers were presented at the rate of one pair every one and one-half seconds, and the number of additions omitted was used as the basis for analysis.

As another control for the effects of demand characteristics, the Digit-Symbol Substitution Task from the Wechsler Adult Intelligence Scale was selected. This task has also been shown to be insensitive to moderate sleep loss. The standard administration of the task requires 1.5 minutes.

Reaction time measures upon awakening. The third type of task used in the experiment was designed to elucidate the relationships between performance and subjective state on the one hand and physiological state on the other. As pointed out in our previous report, reaction time measures have been found to be useful predictors of such variables. Two types of reaction time measures were used. The first was simply the time required for EEG arousal to occur after the awakening bell rang at the end of each sleep period. The second was the time required for the subject to pick up the telephone located beside his bed in response to the awakening bell. These two measures of reaction time should provide an estimate of the motivational and arousal state of the individual.

Evaluations of Subjective State

Because one of our primary interests in the present program of research is in the examination of the effects of sleep and sleep loss on an individual's subjective feeling of well-being, a number of measures of subjective state were employed. The Mood Adjective Checklist (Nowlis, 1970) was administered both before and after the nap, and changes in 11 scales of the checklist were examined for alterations in mood. Feelings about the nap itself were elicited by a set of subjective rating scales designed to measure sleepiness, satisfaction with the nap, and whether the subject's feeling of well-being changes as a function of the nap. We previously reported the usefulness of subjective time estimates in interpreting changes in subjective and physiological states. In the present experiment subjects were asked a series of questions regarding the passage of time during the sleep experiment, such as "How long did it take you to fall asleep?" "How long did you sleep?" "How long has it been since I spoke to you last?" In addition to these paper-and-pencil measures, an extensive postexperimental interview was carried out in order to explore these facets of the experiment in greater detail.

Evaluations of Sleep Patterns

In order to provide extensive information with regard to subjects' regular sleep patterns and habits, as well as to gain detailed information with regard to sleep patterns during the period of time in which the experiment took place, each subject was asked to fill out several sleep questionnaires. Three of them (Patterns of Sleep Questionnaire, Form L; Survey of Subjective Sleep Patterns; Napping Survey) were given once. The fourth was a sleep diary which the subject filled out each day of the experimental period, providing daily information about sleep patterns for each subject for a period of several weeks.

Physiological Recording

Physiological recordings were made in a sound and light shielded chamber, separated by one room from the recording equipment. Microphones provided easy verbal communication between subject and experimenter.

Right frontal (F4), occipital (04), parietal (C4) and left occipital (03) EEG were recorded with reference to the ipsilateral mastoid. Small Beckman biopotential electrodes served as transducers. Left and right EOG were recorded from the outer canthus of each eye with reference to the ipsilateral mastoid using a 6-second time constant. Skin potential and heart rate were also recorded. All measurements were simultaneously recorded on a polygraph and on analog tape for subsequent computer analysis.

Procedure

Subjects were contacted by letter and asked to participate in a study involving learning to perform a motor skill and certain cognitive tasks involving the manipulation of numbers. On arrival they were greeted by Experimenter 1, the nature of the first day's tasks was explained, and the test battery procedure began. Digit-Symbol Substitution, Speeded Addition, Descending Subtraction baselines, Random Number Generation alone, and one minute of practice on the Two-Hand Coordinator were administered. Training to asymptote on the Two-Hand Coordinator was then begun. Training consisted of trials lasting two minutes each; on every fifth trial, the subject was required to perform the Two-Hand Coordinator and Random Number Generation Tasks simultaneously. Training was continued to criterion of 4 consecutive trials of 115 second accuracy, or 30 trials, whichever occurred first. After two-hand coordinator training, the Random Number Generation Task was again presented alone, and additional baselines for the Descending Subtraction Task, Digit-Symbol Substitution, and Speeded Addition were administered. Subjects who met the two-hand coordinator performance criterion of 4 successive trials during which they were on target 115 seconds or more were then rescheduled for Day 2 of the experiment given the first of the sleep questionnaires, a Mood Adjective

Checklist, and a sleep diary.

On Day 2, Experimenter 1 collected the sleep diary and administered again the Descending Subtraction Task, Speeded Addition, Random Numbers Generation alone and combined with the Two-Hand Coordinator and another Mood Adjective Checklist. Then the subject was introduced to Experimenter 2 who explained the nature of the sleep portion of Day 2's experiment in some detail, since subjects had never before participated in a psychophysiological experiment. The electrodes and their mode of attachment were explained, the subject was familiarized with the subjective rating scales, and any questions about the procedure were answered. The Descending Subtraction Task and the Subjective Sleepiness Scale were then administered, electrodes were attached, oral temperature taken, and the subject put to bed. A second Descending Subtraction Task was given, followed by a second Subjective Sleepiness Scale. The subject was then allowed to sleep as much as he wished for a one-hour period, at the end of which he was awakened by a moderately loud bell. Immediately upon awakening he was asked to estimate the length of time since Experimenter 2 last spoke to him, then the Subjective Sleepiness Scale and the Descending Subtraction Task were administered, and the evaluation booklet given. Removal of electrodes was followed by recording post-nap temperature, a fourth Subjective Sleepiness Scale and a fourth Descending Subtraction Task. Experimenter 2 then returned the subject to the waiting room, where he was given additional subjective rating scales.

After completing the last of the post-nap rating scales, the subject was returned to the performance room, where he completed three trials of the combined task, one trial of random numbers alone, the Digit-Symbol Substitution, the Speeded Addition, and finally, the Mood Adjective Checklist. Subjects who maintained the two-hand coordinator criterion on Day 2, and who had scorable EEG on Day 2, were asked to participate in the 3rd, 4th, and 5th days of the experiment. Subjects who agreed to participate in the deprivation portion of the experiment were given new sleep diaries, instructed about the deprivation, and paid in advance for reducing their sleep on the night directly prior to their scheduled participation in Day 3 at the laboratory.

Days 3 and 4 were identical in procedure. The subject had limited his previous night's sleep to three hours. On arrival at the laboratory he was given the Digit-Symbol Substitution, the Speeded Addition, the Random Number Generation alone, and three trials of the combined task. He was then taken to the sleep room, where procedures were exactly as on Day 2, except that it was possible to omit the explanation of electrodes and subjective scales. Two hours after lights in the experimental chamber had been extinguished, the subject was awakened by the bell, and performance tests and subjective scales administered. After completing the sleep portion of the experiment, subjects again performed three trials of the combined task, and then were administered Random Numbers Generation alone, the Digit-Symbol Substitution, the Speeded Addition, and lastly, a postsleep Mood Adjective Checklist.

Day 5 was designed primarily to elucidate some of the variables thought to be relevant to the performance of the Random Numbers Generation Task, and to provide further tests of the practice effect on the Descending Subtraction Task. After completing the tasks, a postexperimental inquiry was conducted by a third experimenter, who had had no previous contact with the subjects.

Results

Preliminary data are available from six subjects who completed all five sessions.

The Effects of Sleep Deprivation

Despite the fact that subjects in the present experiment were exposed to very moderate sleep deprivation, ranging from 3.8 to 5.4 hours less than their usual amount of sleep, significant changes in subjective state and in performance were observed. Comparison between the pre-sleep measures on Day 2, on which no deprivation had been carried out, with those of Day 3, the first deprivation day, indicated that subjects rated themselves as subjectively more sleepy on Day 3 ($t = 3.37$, $p < .01$). In addition, the Mood Adjective Checklist scores demonstrated significantly more fatigue ($t = 4.33$, $p < .005$), less surgency ($t = 2.75$, $p < .025$), less elation ($t = 2.71$, $p < .025$), and less vigor ($t = 2.75$, $p < .025$) on Day 3 than on Day 2. Surprisingly, however, the deprivation was much less effective on Day 4. No significant difference was found between Days 2 and 4 on subjective sleepiness, surgency, or vigor. Significant differences were obtained for both fatigue and elation, but the differences were smaller than for Day 3. Comparison between Days 3 and 4 indicated that subjects slept more deeply ($\underline{t} = 1.98$, $\underline{p} < .05$), were sleepier at the end of the sleep period ($\underline{t} = 2.22$, $\underline{p} < .05$) and took longer to awaken ($\underline{t} = 1.86$, $\underline{p} < .05$) on Day 3 than on Day 4. Sleep time was greater on Day 3 for five of the six subjects. Such findings support the conclusion that deprivation had more pronounced effects on Day 3.

While performance tasks were less affected by the deprivation than were the subjective measures, a deprivation effect was nonetheless demonstrable. Results of the Descending Subtraction Task showed that significantly more items were produced before the first error on the non-deprivation Day 2 than on sleep-deprived Day 3 ($\underline{t} = 3.48$, $\underline{p} < .025$). No significant differences were obtained on mean time per number of percent errors. As expected, the Two-Hand Coordinator Task was not affected by sleep deprivation, but Random Numbers Generation when performed with the Two-Hand Coordinator was less random after sleep deprivation than before. Five of the six subjects showed a difference between the pre-sleep measures on Day 2 and the pre-sleep measures on Day 3; $\underline{t}$-test for paired comparisons between the two days approached significance ($\underline{t} = 1.70$, $\underline{p} < .10$).

Neither the Descending Subtraction Task nor the Random Numbers Generation showed significant deprivation effects on Day 4. The effects of sleep deprivation on performance seem therefore to parallel the subjective effects: if an individual does not feel more tired, less vigorous, and more sleepy after deprivation, little effect on the performance of a well-learned task can be expected.

The performance decrement effects on the sleep-deprived Day 3 become believable when contrasted with the fact that neither the Digit-Symbol Substitution nor the Speeded Addition Tasks which were included in the test battery to help estimate the effects of the demand characteristics inherent in the experimental situation, were depressed by sleep deprivation. The hypothesis that subjects might depress their performance on the pre-sleep deprivation day tasks in order to help conform to the implicit hypothesis of the experiment seems unlikely, since these control performance tasks, with equal face validity, failed to show any differences, while the experimental tasks, on the other hand, did seem responsive to deprivation.

The Effects of Awakening

We have previously reported a decrement in performance on the Descending Subtraction Task when the subject is required to perform the task immediately on awakening. In our previous study, in which moderately sleep-deprived subjects were awakened from either REM or delta sleep, mean time per number, percent errors and decrement scores showed poorer performance immediately upon awakening than prior to the nap, while the number of items before the first error did not. As shown in Table 13, results in the present experiment are consistent with these previous findings. For Days 3 and 4 which were the most comparable to the previous experimental situation, mean time per number increased on awakening,

Table 13. Performance on Descending Subtraction Task

Measure	DAY 2			DAY 3			DAY 4		
	Pre	Awake	Post	Pre	Awake	Post	Pre	Awake	Post
Mean Time per Number	3.87	4.20	3.76	3.76	4.75	4.77	3.52	4.32	3.67
Percent Errors	12.4	19.3	12.7	9.1	19.1	13.5	8.8	16.8	5.4
Decrement Score	--	.09	-.03	--	.24	.21	--	.20	.04
Items before Error	18.5	13.2	18.3	17.3	19.6	23.0	25.8	18.5	39.0

percent errors increased, and there was a significant decrement score: items before the first error actually improved on Day 3, while showing some decrement on Day 4. Although the means of all these comparisons are in the direction expected, with the small number of subjects thus far available few significant differences were observed. Comparisons of pre-nap performance to awakening performance were statistically significant only for percent errors on Day 3. Performance immediately on awakening was significantly lower than post-nap performance for mean time per number on Day 2 and for percent errors and items before the first error on Day 4.

Data from the present experiment show trends similar to those seen in the previous work; however, it should be kept in mind that subjects in the previous study were all awakened from REM or from delta sleep where a much larger decrement could be expected than in the present study in which subjects were awakened from lighter stages of sleep or were sometimes already awake when the bell rang. Only three awakenings occurred from delta sleep, two on Day 3 and one on Day 4. All three awakenings from delta sleep showed a strong performance decrement. No REM awakenings occurred.

The Effects of Recovery from Sleep Loss

To test the hypothesis that even a brief nap would be effective in alleviating the effects of moderate sleep deprivation, our approach has been to select of the two deprivation days, that day which, for a given subject, resulted in greater feelings of sleepiness and greater pre-nap performance decrement. For five of the six subjects, the effects of deprivation were stronger on Day 3; for one subject, Day 4 resulted in the greatest deprivation effects. As a further test of the validity of this division, ratings of the experimenter who conducted the postexperimental interview were compared with subjective sleepiness and performance results; 100% agreement was found. All tests of recovery from sleep loss are therefore based on Day 3 for five of the subjects, and Day 4 for the remaining subject.

Subjective Effects. After the nap, subjects reported being less sleepy ($p < .01$), being satisfied with the nap ($p < .025$), and feeling better in general than before the nap ($p < .01$). No significant differences in the Mood Adjective Checklist were observed as a function of the nap.

Descending Subtraction Task. In our previous study, during which subjects were awakened from Stages Delta or REM after comparable deprivation, we found that only the items before the first error showed an improvement as a function of the nap. In the present study, although there is a trend in the expected direction, no significant differences between pre- and post-nap performance were found for this variable.

Random Number Generation. The subjective organization score of the Random Number Generation Task when performed alone showed no significant difference between pre- and post-nap performance, although four of the six subjects showed improvement after the nap. The extent, however, to which performing the task in combination with the Two-Hand Coordinator was affected by recovery from sleep loss, approached significance ($t = 1.79$, $p < .10$).

Correlational analyses. Since subjects differed widely in the amount of time slept, in the amount of time during which they were spontaneously awake before the awakening bell rang, and in the composition of their sleep time, results were subjected to correlational analysis. The large number of variables together with the small number of subjects make the interpretation of correlational analyses particularly difficult. Since many of the statistically significant correlations could be expected by chance, separate correlational matrices were computed for Day 3 and Day 4. The pattern of correlations was quite different for Day 3 than it was for Day 4, and in many regards Day 4 more closely resembles Day 2 where the nap itself was very brief and without any prior deprivation. In view of the lack of internal consistency within these data and the small sample from which they were obtained, it does not seem appropriate to report them here.

Differences between Day 3 and Day 4. As has already been discussed, subjects reported considerably more fatigue and indeed showed more objective deprivation effects on Day 3 than Day 4. A careful analysis of sleep diaries indicated no difference between the amount of deprivation on the two days nor in the amount of sleep that subjects had obtained in the nights preceding the deprivation night. They spontaneously reported themselves to be more sleepy following the sleep deprivation on Day 3 than on Day 4.

The effect of sleep deprivation on the tendency to sleep. Originally we had not intended to subject the adaptation nap on Day 2 to detailed analysis. Since it was the subjects' first nap in the laboratory, it seemed more likely to reflect their response to the situation than their napping behavior. However, the data were analyzed, in part to help clarify the peculiar differences between Day 3 and Day 4. The most interesting and striking observation was the extent to which the amount of sleep on Day 2 helped predict the amount of sleep obtained on Days 3 and 4. The rank order correlation between the percent of sleep per time available in an undeprived situation and the second nap was .97. The correlation between the second day and the fourth day was 1.00; and between the third and fourth days, .93. It was apparent that the sleep pattern of an individual is a more significant determinant of whether he is able to nap in the laboratory than the amount of fatigue prior to the nap, at least within the relatively narrow limits of our observations.

Discussion

Limited by the amount of data available, the results are encouraging in suggesting that the subjective effects of sleep loss are paralleled by those on performance. We were surprised to find the striking difference between the effects of sleep deprivation on Day 3 and Day 4. Since no differences could be established in the amount of actual sleep obtained, it seems necessary to entertain the hypothesis that these differences are a function of psychological rather than physiological effects. In postexperimental interviews it became apparent that subjects approached the initial day of sleep restriction with some trepidation and had anticipated far more profound effects of limiting their sleep than those actually experienced.

While they were tired after limiting their sleep, they were surprised to find themselves able to function better than they had expected. Consequently, when asked to repeat this experience, they felt less concerned and reported that they felt better able to tolerate sleep loss since they knew they had done so the preceding week. This observation, if validated, may, in its own right, be of some practical significance; however, from the point of view of learning more about the salutary effects of napping, it suggests the need to modify our procedures.

The continuation study will follow the same model. However, while Day 3 will be run as in the present study, Day 4 will require a further limiting of the prior night's sleep to only two hours. By limiting sleep further on the second day of deprivation, it is expected to maintain the psychological as well as the physiological effects of being sleep-deprived. An additional modification will be to select a time for the nap which coincides with the time of day when the subject typically feels tired as indicated from an evaluation of his daily reports in the sleep diary. Obviously, the study of recovery from fatigue can be efficiently carried out only by assuring that subjects are indeed tired prior to the napping.

When the present study was designed it was felt desirable to have information on the effect of napping on performance in an unselected population. While ultimately such parametric information is important, it is relatively inefficient at this early stage of research, especially when the number of sessions required for each subject makes the costs of large samples prohibitive. It turned out that only one subject among the six who were run adequately satisfied the criteria of being a napper, while one additional subject met some of the napper criteria. Clearly, the effects of napping on performance are most likely to be pronounced among those subjects who habitually nap. Accordingly, the new nap questionnaire which we have developed will be used to select a more homogeneous population of subjects. Further, the ability to sleep in the laboratory will be used as an additional criterion. For this purpose an additional day will be added to the study for the sole purpose of selecting appropriate individuals. Only those subjects who are able to sleep at least 40 minutes of the hour that is provided for their first nap will be included in the study. While the initial sample will emphasize individuals who are habitual nappers, an effort will also be made to include some subjects who actively dislike napping but who fall asleep easily. We would hope that these individuals will match the laboratory sleep propensity of the nappers and provide a contrast for them. Even if these subjects are relatively limited in number, they will serve the important function of keeping the experimenters who have actual contact with the subjects blind concerning the individuals' habitual napping patterns.

SUMMARY

Over the past two years our understanding of napping behavior has been altered and expanded. Clearly, daytime sleep may serve a number of functions, only one of which involves the replacement of nighttime sleep. Those individuals who habitually take naps find them quite satisfying and useful in relieving both fatigue and anxiety; beyond that, however, naps often are a source of positive gratification. This is perhaps analogous to appetite or, as a specific example, to nibbling on candy--not in order to assuage hunger, but simply for enjoyment.

Though sleep is necessary for the effective functioning of individuals, it has been difficult to establish how much and what kinds are truly necessary. The effects of sleep loss are likely to be subtle, just as are the effects of nutritional deficiencies. In the latter case, however, some gross measures such as weight loss are useful, though subtler deficiencies are more difficult to identify. At the present time, performance measures seeking to evaluate cognitive disturbances may be considered the most meaningful criterion measures of the immediate effects of sleep loss. On the other hand, there is likely to be an important interaction between motivation and sleep deprivation. Thus, apathy is one of the characteristics of fatigued individuals; by the same token, strong incentives may temporarily overcome these motivational deficits. The methodology of Alluisi and his associates, using the worklike situation, provides some measure of these motivational effects that are usually obscure in other approaches. Though we have come to feel that such procedures may ultimately be necessary, it is clear that they are sufficiently costly that they can be employed only at a late hypothesis-testing stage and are not feasible at a time when the basic parameters have yet to be established.

An alternative approach seems productive. Instead of using performance in a stable work situation as a measure of both cognitive and motivational deficit, we have chosen to evaluate separately the cognitive deficit under motivated circumstances and the subjective state of the individual. We hope to be able to pick up evidence of cognitive deficit by the choice of appropriate performance measures. Equally important, however, is the effort to measure those subjective changes which would in a life situation also reflect themselves in performance decrements though their effects are easily masked in the laboratory context. We have been encouraged by the coherence of a number of our subjective measures and their moderate relationship with performance decrement. This supports our view that an efficient means of assessing motivational effects of sleep deficit is by way of assessing subjective experience. Such an approach, while still costly, does make it feasible to relate the physiological nature of napping behavior to its restorative functions.

Questionnaire material supports anecdotal evidence that the use of napping varies widely within normal populations, and that it is habitually employed by a surprisingly large number of college students. Preliminary data comparing habitual nappers and non-nappers suggest that there are interesting differences in physiological napping patterns. It would appear that the knowledge of the amount of time available for sleep has a profound effect on the nature of the sleep cycle that occurs. While sufficient data are not yet available, it would appear that nappers have a greater ability to control the nature of their physiological sleep activity. Of special interest in this context is the function of Stage I sleep which the habitual napper does not seem to experience as sleep while the non-napper does.

To our surprise, we have observed that slow wave sleep, even during the two-hour nap, is largely counterproductive. The more slow wave sleep that occurs, the worse the performance and the less satisfying the experience. This has been observed both in the absence of sleep deprivation and with moderate amounts of sleep deprivation, but in view of the work by Webb and others, it does not seem true for somewhat longer periods of sleep such as four hours. Thus the function of slow wave sleep in facilitating recovery from fatigue is paradoxical in relatively brief naps. The extent to which this may account for the differences between nap satisfaction and the overall tendency to nap has yet to be established.

Within the very narrow limits of sleep deprivation which we have examined, it appears that an individual's innate sleep propensity is far more important in establishing the percentage of time he will sleep in the laboratory situation than the amount of fatigue he reports prior to sleep. This finding must be interpreted cautiously since it may hold only when an individual is not adapted to a novel context whereas sleep patterns are modified by long-term needs. This, again, could be analogous to making up nutritional deficits, which is usually accomplished over a period of time, and the amount of food consumed at a given meal is determined more by habits of food intake than by the length of time that has elapsed since the last feeding.

We continued to be interested in developing means of training individuals to fall asleep and obtain the kind of sleep that has maximal restorative functions. In this context, pilot studies of sleep onset are continuing. However, efforts to shape sleep patterns will need to await more reliable information about the kind of nap which is truly satisfying to the individual and leads to improved performance. The study now in progress should help provide much of the basic information which is required to determine how best to train individuals to nap efficiently.

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Appendix A

Unit for Experimental Psychiatry
Institute of the Pennsylvania Hospital

Sleep Questionnaire

Name:________________________________Age:____Sex:____Date:________

Occupation:____

(If student, give institution)________________________________

Local Address:____

____Telephone:__________

Instructions:

People differ greatly in how they sleep and dream. We are interested in obtaining information on the frequency of occurrence of various patterns of sleeping and dreaming. We would greatly appreciate your cooperation in giving us information on how you sleep and dream by filling in this questionnaire.

Please answer each question by checking the appropriate descriptive term (or circling the appropriate numbers, where this is indicated).

Please answer every question.

---

1. Do you dream at night?
   ___always ___usually ___sometimes ___rarely ___never

2. Do you have nights of dreamless sleep?
   ___always ___usually ___sometimes ___rarely ___never

3. Do you have periods during the night when you have thoughts running through your head but are not actually dreaming?
   ___always ___usually ___sometimes ___rarely ___never

4. On awakening in the morning, are you unable to remember dreaming even though you are sure you did dream?
   ___always ___usually ___sometimes ___rarely ___never

5. Do you wake up during the night?
___always ___usually ___sometimes ___rarely ___never

6. Are you a deep sleeper?
___always ___usually ___sometimes ___rarely ___never

7. Have you ever heard a sound in a dream that you found upon awakening was actually there?
___always ___usually ___sometimes ___rarely ___never

8. Do you have nightmares at night?
___always ___usually ___sometimes ___rarely ___never

9. Do you fall asleep easily?
___always ___usually ___sometimes ___rarely ___never

10. Do you have to get up during the night?
___always ___usually ___sometimes ___rarely ___never

11. Do you talk in your sleep?
___always ___usually ___sometimes ___rarely ___never

12. Are you a light sleeper?
___always ___usually ___sometimes ___rarely ___never

13. Do you dream about things that happened during the day?
___always ___usually ___sometimes ___rarely ___never

14. Do you dream in color?
___always ___usually ___sometimes ___rarely ___never

15. If you expect to hear a sound during the night while sleeping, would that sound be likely to awaken you even though it were not very loud? (For example, if you were expecting your roommate to come in late, and he did so even quietly while you were asleep.)
___always ___usually ___sometimes ___rarely ___never

16. Are you able to sleep late on Sundays?
___always ___usually ___sometimes ___rarely ___never

17. Do you take cat naps during the day?
___always ___usually ___sometimes ___rarely ___never

18. Do you find yourself oversleeping when you have an appointment you would rather avoid?
___always ___usually ___sometimes ___rarely ___never

19. Do you have difficulty falling asleep?
___always ___usually ___sometimes ___rarely ___never

20. Do you take sleeping medications?
___always ___usually ___sometimes ___rarely ___never

21. Do you have trouble going to sleep in strange surroundings?
___always ___usually ___sometimes ___rarely ___never

22. Do you like to sleep?
___always ___usually ___sometimes ___rarely ___never

23. While you are dreaming, can you change the content of your dream at will?
___always ___usually ___sometimes ___rarely ___never

24. Can you decide beforehand what you are going to dream about?
___always ___usually ___sometimes ___rarely ___never

25. Do you ever go to sleep during a movie or theatre performance, or during a concert?
___always ___usually ___sometimes ___rarely ___never

26. Can you go to sleep at will on a long plane trip or car trip?
___always ___usually ___sometimes ___rarely ___never

27. Can you set yourself to wake up at whatever time you choose in the morning?
___always ___usually ___sometimes ___rarely ___never

28. Can you go to sleep at will?
___always ___usually ___sometimes ___rarely ___never

29. Do you have trouble sleeping the night before exams or other important events?
___always ___usually ___sometimes ___rarely ___never

30. What time of day do you work best?
___early morning ___morning ___midday ___late afternoon
___early evening ___early night ___late at night

31. If you could choose your own schedule of sleep, what hours would you choose? (Please circle them)
AM: 1 2 3 4 5 6 7 8 9 10 11 noon
PM: 1 2 3 4 5 6 7 8 9 10 11 midnight

32. How many hours of sleep do you need at night? (Please circle one)
Less than 3, 4, 5, 6, 7, 8, 9, 10, more than 10

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Three studies are reported on: (1) A factor analytic investigation of questionnaire data to help establish the attributes of individuals who habitually nap as opposed to others who do not. (2) A study over eight sessions comparing the physiological napping behavior of habitual nappers versus individuals who do not normally nap. (3) A study currently in progress evaluating the effect of napping on performance in partially sleep-deprived individuals. Previous observations about the deleterious effects of naps involving delta sleep on performance

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immediately on awakening were again observed. One of the more striking findings is that nappers seem to perceive descending Stage I sleep as more like being awake while non-nappers describe it as sleep. Further, it would appear that daytime napping serves appetitive functions in addition to facilitating recovery from fatigue in non-sleep-deprived habitual nappers. The likelihood that there are functional differences in napping behavior between nappers and non-nappers is discussed.